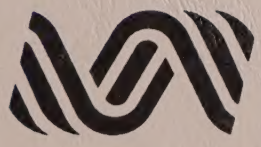
INSTRUCTION MANUAL
C15003iH/3-3HGA-4740

Invertron®



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California Instruments

Revision A

INSTRUCTION MANUAL
C15003iH/3-3HGA-4740

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Manual Addendum
for
C15003iH/3-3HGA-4740

1. General

The C15003iH/3-3HGA-4740 is a standard C15003iH/3-3HGA wired with an OMNI 3-18 impedance network and front panel system output connectors.

2. Specifications

Specifications for the C15003iH/3-3HGA-4740 are the same as the standard C15003iH/3-3HGA except as noted below.

Output Current	20 A max on single phase connectors (J1, J2, J3) 30 A max on three phase connector (J4)
Output Connectors	Hubbell 2320 (single phase outputs J1, J2, J3) Hubbell 2810 (three phase output J4)

3. Operation

Operation of the C15003iH/3-3HGA-4740 is similar to the standard system except that an OMNI 3-18 is in series with the outputs (with Bypass switch) and the outputs are available on front panel connectors. The output connectors are protected by adjacent circuit breakers. These circuit breakers limit the output current to the rating of the connector rather than the rating of the 5001iH power source.

California Instruments

Revision G
December 1997

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P/N 7000-963

i-Series AC Power Source
User Manual- Section 1
SCPI Programming Manual- Section 2

User's Manual
AC Power Source
California Instruments
Models :

- 3001i
- 5001i
- 5001i-400
- 10001i
- 10001i-400
- 15001i
- 15001i-400
- 15003i
- 15003i-400

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SAFETY SUMMARY

This power source contains high voltage and current circuits which are potentially lethal. Because of its size and weight, mechanical stability must be ensured. The following safety guidelines must be followed when operating or servicing this equipment. These guidelines are not a substitute for vigilance and common sense. California Instruments assumes no liability for the customer's failure to comply with these requirements. If the power source is used in a manner not specified by California Instruments the protection provided by the equipment may be impaired.

BEFORE APPLYING POWER

1. Verify the correct voltage is applied to the unit (for example 240V).

2. The chassis and cabinet of this power source must be grounded to minimize shock hazard. A chassis ground is provided at the input terminal block. This is located at the back of the cabinet on the lower right hand side. The chassis ground must be connected to an electrical ground through an insulated wire of sufficient gauge.

FUSES

Use only fuses of the specified current, voltage, and protection speed (slow blow, normal blow, fast blow) rating. Do not short out the fuse holder or use a repaired fuse.

DO NOT OPERATE IN A VOLATILE ATMOSPHERE

Do not operate the power source in the presence of flammable gases or fumes.

DO NOT TOUCH ENERGIZED CIRCUITS

Disconnect the power cable before servicing this equipment. Even with the power cable disconnected, high voltage can still exist on some circuits. Discharge these voltages before servicing. Only qualified service personnel may remove covers, replace components or make adjustments.

DO NOT SERVICE ALONE

Do not remove covers, replace components, or make adjustments unless another person, who can administer first aid, is present.

DO NOT EXCEED INPUT RATINGS

Do not exceed the rated input voltage or frequency. Additional hazards may be introduced because of component failure or improper operation.

DO NOT MODIFY INSTRUMENT OR SUBSTITUTE PARTS

Do not modify this instrument or substitute parts. Additional hazards may be introduced because of component failure or improper operation.

MOVING THE POWER SOURCE

When moving the power source, observe the following:

1. Remove all AC power to unit.

2. Use two people to prevent injury.

SAFETY SYMBOLS:

THIS SYMBOL INDICATES DIRECT CURRENT

THIS SYMBOL INDICATES ALTERNATING CURRENT

THIS SYMBOL INDICATES BOTH DIRECT AND ALTERNATING CURRENT

THIS SYMBOL INDICATES THREE–PHASE ALTERNATING CURRENT

THIS SYMBOL INDICATES EARTH (GROUND) TERMINAL

THIS SYMBOL INDICATES PROTECTIVE CONDUCTOR TERMINAL

THIS SYMBOL INDICATES FRAME OR CHASSIS TERMINAL

THIS SYMBOL INDICATES ON (SUPPLY)

THIS SYMBOL INDICATES OFF (SUPPLY)

THIS SYMBOL INDICATES CAUTION, RISK OF ELECTRIC SHOCK

THIS SYMBOL INDICATES CAUTION (REFER TO ACCOMPANYING DOCUMENTS)

ONE YEAR WARRANTY

CALIFORNIA INSTRUMENTS CORPORATION warrants each instrument manufactured by them to be free from defects in material and workmanship for a period of one year from the date of shipment to the original purchaser. Excepted from this warranty are fuses and batteries which carry the warranty of their original manufacturer where applicable. CALIFORNIA INSTRUMENTS will service, replace, or adjust any defective part or parts, free of charge, when the instrument is returned freight prepaid, and when examination reveals that the fault has not occurred because of misuse, abnormal conditions of operation, user modification, or attempted user repair. Equipment repaired beyond the effective date of warranty or when abnormal usage has occurred will be charged at applicable rates. CALIFORNIA INSTRUMENTS will submit an estimate for such charges before commencing repair, if so requested.

PROCEDURE FOR SERVICE

If a fault develops, notify CALIFORNIA INSTRUMENTS or its local representative, giving full details of the difficulty, including the model number and serial number. On receipt of this information, service information or a Return Material Authorization (RMA) number will be given. Add RMA number to shipping label. Pack instrument carefully to prevent transportation damage, affix label to shipping container, and ship freight prepaid to the factory. CALIFORNIA INSTRUMENTS shall not be responsible for repair of damage due to improper handling or packing. Instruments returned without RMA No. or freight collect will be refused. Instruments repaired under Warranty will be returned by prepaid surface freight. Instruments repaired outside the Warranty period will be returned freight collect, F.O.B. CALIFORNIA INSTRUMENTS 9689 Towne Centre Drive San Diego, CA 92121. If requested, an estimate of repair charges will be made before work begins on repairs not covered by the Warranty.

DAMAGE IN TRANSIT

The instrument should be tested when it is received. If it fails to operate properly, or is damaged in any way, a claim should be filed immediately with the carrier. A full report of the damage should be obtained by the claim agent, and a copy of this report should be forwarded to us. CALIFORNIA INSTRUMENTS will prepare an estimate of repair cost and repair the instrument when authorized by the claim agent. Please include model number and serial number when referring to the instrument.

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1. Introduction

This instruction manual contains information on the installation, operation, calibration and maintenance of all power systems that use the 3001i and 5001i power sources with the programmable controller.

1.1 General description

The 3001i and 5001i are high efficiency, light weight AC power sources that provide a precise output with low distortion. The output has two ranges, either 0-135V or 0-270V and full power is available at the maximum output voltage. Two or three 5001i units can be connected in parallel as a single phase system for 10 kVA or 15 kVA respectively. When two or three units are operated in parallel they can only be used in the AC Mode. Three units can be connected as a three phase system where each unit is a master with its own controller, synchronized using clock and lock, and they can be operated with AC or DC output.

2. Specifications

All specifications are for a single i-Series chassis and 25± 1°C unless noted otherwise.

2.1 Electrical

2.1.1 Input

Line Voltage:	
3001i	208-240 ±10% VAC, single phase
5001i	208-240 V_{LL} ±10% , 400-440 V_{LL} ±10%
	or 400-480 V_{LL} ±10%
	3 phase, 3 wire + ground
Line VA: :	
3001i	5000VA
5001i	8000VA
Line Current:	
3001i	25 A RMS max.
5001i	23 A RMS max. at 208-240 VAC
	12 A RMS max. at 400-440 VAC and 400-480 VAC
Line Frequency:	50-60 Hz ±10%
Efficiency:	80% (typical) depending on line and load
Power Factor:	
3001i	0.7 (typical)
5001i	0.9 (typical)
Inrush Current:	100 A_{pk} for 100 µs at 208-240V
	50 A_{pk} for 100 µs at 400-440 VAC and 400-480 VAC
Hold-Up Time:	15 ms
Isolation Voltage:	2200 VAC input to output
	1350 VAC input to chassis

2.1.2 Output

(ALL SPECIFICATIONS ARE FOR AC & DC UNLESS NOTED OTHERWISE)

Voltage Range:	0 to 135 or 270
Voltage Resolution:	0.1 volt
Voltage Accuracy:	±0.5% or range, 16 to 400 Hz.
Voltage Distortion:	1% max THD at 50/60 Hz, 2% max THD at 400 Hz (linear load)
Load Regulation:	± 0.5% DC to 100 Hz.
Load Regulation	± 2.2% to 500 Hz (135 range)
Load Regulation	± 0.6% to 500 Hz (270 range)
Line Regulation:	0.1% for 10% input line change
Power:	
3001i	3000 VA maximum at full scale voltage, either range, AC only (1500W DC)
5001i	5000 VA maximum at full scale voltage, either range, AC only (2500W DC)
10001i	10000 VA maximum at full scale voltage, either range, AC only
15001i	15000 VA maximum at full scale voltage, either range, AC only
15003i	15000 VA maximum total at full scale voltage, either range, AC only
	5000 VA maximum per phase
Current, max.:	
3001i	22.2 arms for 135 VAC range
	11.1 arms for 270 VAC range
5001i	37 arms for 135 VAC range
	18.5 arms for 270 VAC range
	(Derated linearly from 50% of voltage to 10% of specified current at 5% of voltage range)

Current Limit:	AC 135V range:	AC 270V range:	DC 135V range:	DC 270V range:
3001i	0 to 22.2	0 to 11.1	0 to 11.1	0 to 5.56
5001i & 15003i	0 to 37	0 to 18.5	0 to 18.5	0 to 9.25
10001i	0 to 74	0 to 37	n/a	n/a
15001i	0 to 111	0 to 55.5	n/a	n/a

Frequency Range:	16.00 - 81.91 Hz (0.01 Hz resolution)
	81.0 - 500.0 Hz (0.1 Hz resolution)
Frequency Accuracy:	±0.01% of program value

DC Offset Voltage:	Less than 20 mV with linear load.
Output Noise:	400 mV RMS on 135 range, 800 mV RMS on 270 range
Peak Rep AC Current:	110 A for 135 V range, 92 A for 270 V range
Crest Factor:	Up to 5:1

2.1.3 Measurements

(ALL SPECIFICATIONS ARE FOR AC & DC UNLESS NOTED OTHERWISE)

Voltage (TRMS)	0.1 volt resolution, ± 0.5 volts accuracy.
Current (TRMS)	
5001i, 15003i	± 0.5 amp Accuracy, 0.1 amp Resolution
10001i, 15001I	± 5 amp Accuracy, 1 amp Resolution
Peak Current:	
5001i, 15003i	± 0.5 amp Accuracy, 0.1 amp Resolution
10001i, 15001i	± 5 amp Accuracy, 1 amp Resolution
True Power:	
5001i, 15003i	± 0.05 kW AC, ± 0.15 kW DC Accuracy, 0.01 kW Resolution
10001i, 15001i	± 0.5 kW AC Accuracy, 0.1 kW Resolution:
Apparent Power(VA):	
5001i, 15003i	0.20 kVA Accuracy, 0.01 kVA Resolution
10001i, 15001i	2.0 kVA Accuracy, 0.1 kVA Resolution
Frequency:	
16.00 - 99.99 Hz	± 0.02 Hz Accuracy, 0.01 Hz Resolution
100.0 - 500.0 Hz	± 0.2 Hz Accuracy, 0.1 Hz Resolution

2.1.4 System Specification

External Modulation:	10 volt input for 30% change in output.
Synchronization Input:	Isolated TTL input for external frequency control. Requires 5V at 5 ma for logic high.
Trigger Output:	400 μs high pulse for voltage or frequency change. Isolated output that requires a pull-up resistor, 22K, to ± 5 VDC.
Non volatile memory storage:	8 complete instrument setups and transient lists, 32 events per list.

Transient types:	Voltage drop, voltage step, voltage sweep
	Voltage sag/surge, Frequency sweep, Frequency step
	Voltage and frequency sweep
IEEE-488 Interface:	SH1, AH1, T6, L3, SR1, RL2, DC1, DT1
	IEEE 488.2 & SCPI
	Response time is 10 ms (typical)
RS232C Interface:	Bi-directional serial interface
	9 pin D-shell connector
	Handshake: CTS, RTS
	Data bits: 7, 8
	Stop bits: 1,2
	Baud rate: 1200, 2400, 4800, 9600
	IEEE 488.2 and SCPI
Current Limit Modes:	Two selectable modes of operation.
	Constant current and constant voltage with hold-off time and trip.

2.1.5 Unit protection

Input Overcurrent:	Circuit breaker with shunt trip control.
Input Overvoltage:	Automatic shunt trip of input circuit breaker.
Input Overvoltage Transients:	Surge protection to withstand EN50082-1 (IEC 801-4, 5) levels.
Output Overcurrent:	Adjustable level constant current mode with a maximum set point at 10% +/- TBD% above programmed value.
Output Overvoltage:	220 V +/- 10 volt peak for 135 volt range
	420 V +/- 20 volt peak for 270 volt range.
Output Short Circuit:	Peak current limit. Foldback with automatic recovery.
Overtemperature:	Automatic shutdown and recovery.

2.2 Mechanical

Dimensions:	19" (483 mm) wide x 7" (178 mm) high x 24" (610 mm) deep chassis size which is available in a rack mount or stand-alone configuration.
Unit Weight:	61 lb. (28 kg)
Material:	Aluminum chassis, panels and cover.

Finish:	Light textured painted external surfaces.
	Front and rear panels semi-gloss polyurethane color no. 26440 (medium gray)
	Top, bottom and sides semi-gloss polyurethane color no. 26622 (light gray).
Cooling:	Fan cooled with air intake on the sides and exhaust to the rear.
Internal Construction:	Modular sub assemblies.
Rear Panel Connections:	(see section 3 for description of connections)
	Input terminal block with cover
	Output terminal block with cover
	Remote voltage sense terminal block
	System interface (not for table top use, use only in rack enclosed systems)
	Clock and Lock (not for table top use, use only in rack enclosed systems)
	RS232
	GPIB

2.3 Environmental

Operating Temp:	0 to +40 °C.
Storage Temp:	-40 to +85 °C.
Altitude:	<2000m
Relative Humidity:	80% maximum for temperatures up to 31°C decreasing linearly to 50% at 40°C.
Installation/Overvoltage:	
Category:	II
Pollution Degree:	2
Indoor Use Only	
Vibration:	Designed to meet NTSA 1A transportation levels.
Shock:	Designed to meet NTSA 1A transportation levels.

2.4 Regulatory

Electromagnetic Emissions and Immunity:	Designed to meet EN50081-2 and EN50082-2 European Emissions and Immunity standards as required for the "CE" mark.
Acoustic Noise:	65 dBA maximum at 0% to 50% load, 75 dBA maximum greater than 50% load to 100% load. Measured at one meter.
Safety:	Designed to meet UL3111 and EN61010-1 European safety standards as required for the "CE" mark.

2.5 Front panel controls

Controls:

Shuttle knob:	Allows continuos change of all values including output calibration and range change.
Decimal keypad:	A conventional decimal keypad facilitates quick entry of numerical values such as voltage, current limit etc. The large blue enter key will make the value you enter effective. Using the SET key allow the user to preset all parameter values and update them all at once by pressing the Enter key.
Up/down arrow keys:	A set of up and down arrow keys is used to move the cursor position in all menus. This allows quick selection of the desired function or parameter.
Function keys:	Measure key will display most measurement values. Program key will show all program parameters. Output on/off key for output relay control.

Displays:

LCD graphics display:	A large high contrast LCD display with backlight provides easy to read guidance through all setup operations. An adjustable viewing angle makes it easy to read from all practical locations.
Status indicators:	Large and bright status indicators inform the user of important power source conditions. The Remote lamp informs the user that the unit is under remote control. The Overload lamp indicates that excessive current is being drawn at the output. The Overtemperature lamp illuminates when internal heatsink temperatures are too high. The Hi Range indicator is lit any time the unit is switched to high output voltage range. The Output On/Off indicator is on when the power source output relays are closed.

2.6 Special features and options

Parallel Operation:	Can parallel up to three units in a single phase configuration (with one master controller and one or two slave units in AC mode only).
Three Phase Output:	Can connect three units (all with controllers) in a three phase configuration using CLOCK and LOCK connections.
Rack Mount/Handles Version:	Available rack mounting kit with slides and handles. Handles also available as a separate option.
Controller:	Programmable controller front panel assembly.
Output Relay:	Standard output relay feature to isolate AC source from the load.
Output On/Off:	The output relay can be used to quickly disconnect the load. A green status indicator displays the status of the output relay.

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3. Unpacking and Installation

3.1 Unpacking

Inspect the unit for any possible shipping damage immediately upon receipt. If damage is evident, notify the carrier. ***DO NOT*** return an instrument to the factory without prior approval. Do not destroy the packing container until the unit has been inspected for damage in shipment.

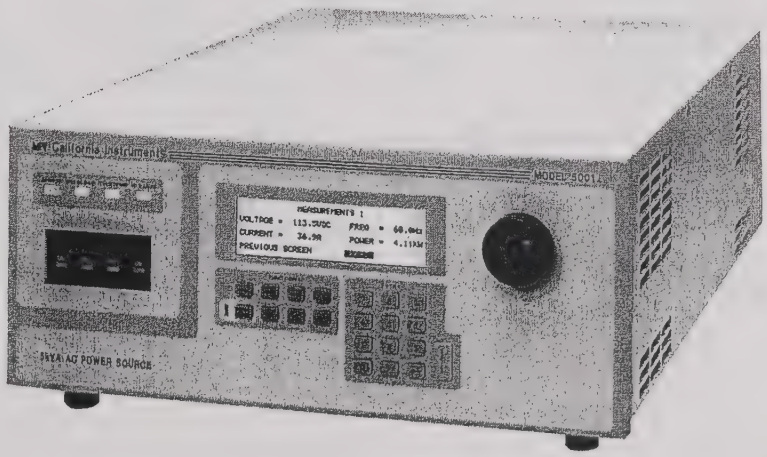
WARNING: This power source weighs 61 lb (28kg). Obtain adequate help when moving or mounting the unit.

3.2 Power requirements

The 3001i AC Power Source has been designed to operate from a single phase 208 to 240 volt AC line. The 5001i AC Power Source and its systems have been designed to operate from a three phase AC line voltage. Two three phase input models are available. One model operates from 208V to 240V input line and the other model operates from 400V to 480V line.

CAUTION: Do not connect 400-480V into the 208-240V unit, the result could be a severely damaged unit.

Figure 3-1: The 5001i Power Source



3.3 Mechanical installation

The 3001i and 5001i are a completely self contained power sources. They may be used free standing on a bench top or rack mounted using the optional rack mount/handle kit. The units are fan cooled, drawing air in from the sides and exhausting at the rear. The sides of each unit must be kept clear of obstruction and a 6" clearance must be maintained to the rear. See Figure 3-1.

3.4 Input wiring

The input terminal block, TB1, is located at the rear of the unit. Ground or earth wire must be connected to the chassis of the AC power system. The mains source must have a current rating equal to or greater than the input circuit breaker and the input wiring must be sized to satisfy the applicable electrical codes.

3.5 Output connections

3.5.1 Output wiring

The output terminal block, TB2, is located at the rear of the unit. The external sense inputs allow the power system output voltages to be monitored directly at the load and must be connected either at TB2 or the load when the sense is programmed for external. The external sense input does not have to be connected when Internal Sense is programmed. The external sense wires are to be connected to TB3 on the rear panel and should be run as a twisted pair for short lengths. Sense leads over three (3) feet long should be run as a twisted shielded pair. Refer to Figure 3-2 for all connections.

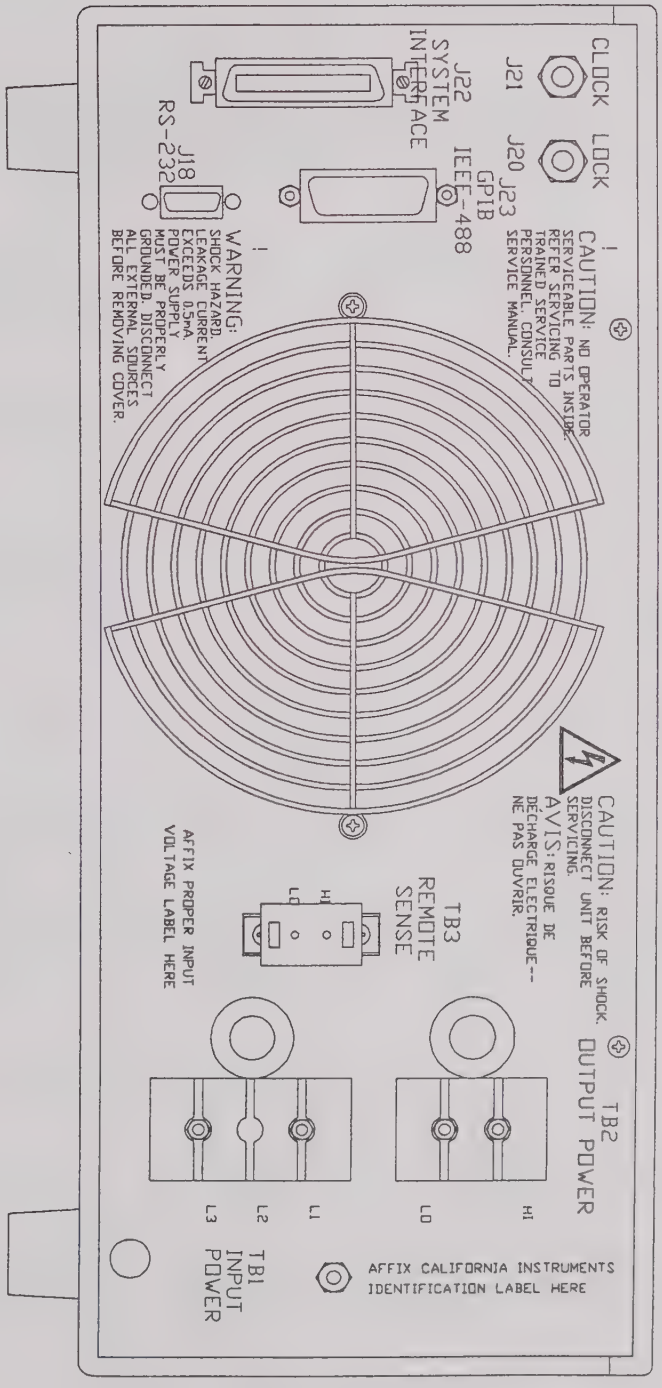
The output of the power source may be grounded or left floating.

3.5.2 System Interface, Clock and Lock connectors

J21 and J20 are the Clock and Lock connectors and are used to synchronize and control the phase shift between the three outputs when 3 units are operating as a three phase system.

WARNING: The system interface connector and Clock and Lock connectors may be at hazardous voltages. These connections may not be used in table top applications. In table top applications the safety cover must be in place. These connections may only be used when the equipment is enclosed in a rack, only within one rack, only with California Instruments supplied cables, and only between California Instruments equipment.

Figure 3-2: Rear Panel View



The output power cables must be large enough to prevent a total voltage drop exceeding 1% of the rated output voltage between the power source and the load. Table 1 shows the AWG size of the cables that may be used. Cable lengths must not exceed twenty-five (25) feet. For lengths greater than 25 feet, calculate the voltage drop from the following formula:

2 X DISTANCE X CABLE RESISTANCE PER FT. X CURRENT = VOLT DROP

Table 1 : Wire Sizes

LOAD CURRENT	WIRE GAGE
22 AMPS	10 AWG
37 AMPS	8 AWG
74 AMPS	4 AWG
111 AMPS	2 AWG

3.5.3 Single-phase and three phase multiple box system configurations

Three Phase System:

The three phase system will be configured ready for use when ordered as such from the factory. One unit will be identified as the master and the other two units will be identified as slaves. The master will control the frequency of the two slaves but the frequency range switch must be in the same position on all units. The voltage of each phase is independently controlled from the control on the front of each box.

The three units must be interconnected using the ***clock and lock cables*** and the three **LO** outputs must also be connected together before applying power. ***Do not connect the system interface cable.***

If the units were purchased as single phase units and have not been configured for a three phase system please consult the factory.

Single Phase System:

In a single phase system consisting of two or three units there will be one master unit that will have a full controller and the slaves will have blank front panels except for the circuit breaker and power-on light.

The units must all be connected with the system interface cable, ***but not the clock and lock cables.*** The HI outputs on all the terminal block's should be connected together. The LO outputs should all be connected together and a heavy duty cable run to the load from the HI and LO outputs. See Table 1 for cable sizing.

The appropriate jumpers have all been installed at the factory before shipment. If it becomes necessary to change the system to three phase please consult the factory.

3.6 Output voltage ranges.

The power source has two standard ranges 0-135V and 0-270V. The operator may switch from one range to the other at will with no special precautions except to remember that the output voltage will go to zero voltage when changing from the low range to the high range.

3.7 Functional Test

CAUTION: Work carefully when performing these test, hazardous voltages are present on the input and output during this test..

Refer to Figure 3-3 for the test set up.

1. Connect an oscilloscope, voltmeter and/or distortion analyzer to the AC source output at the output terminal block (L2).

2. With the AC mains verified as being off, apply the correct three phase AC power input voltage connections to the AC source input terminals barrier (L1). Apply the AC mains power and turn on the main circuit breaker on the AC source front panel.

3. Verify the front panel LCD display lights up with the initial start up screen showing the unit ID and serial number. A self check routine screen with follow and finally the system will display the main "Menu 1" screen with the cursor highlighting the "Program" selection.

4. Press "ENTER" and the unit will display the Program selection screen. Set the following output parameters: output voltage = 135 volts, frequency = 60 Hz, voltage range = 135 volts, and current limit = 22.2 amps (3001i) or 37 amps (5001i). Press "ENTER".

5. Enable the output by pressing the output "on/off" button below the front panel display screen. The green LED next to the button will light green when the output is on. The output should be a clean 135 volt AC sinewave having less than 1% distortion.

6. Apply full load to the output of the source and verify the output remains within 2% of the initial 135 volt value. The output should still be clean and the distortion should still be less than 1% at 60 Hz.

7. Using the PROGRAM screen set the output current limit value to 18 amps. The system should go into current limit. Return the current value to 22.2 amps (3001i) or 37 amps (5001i) and press the output on/off button to turn the output off. Disconnect the load.

8. Repeat steps 4 through 7 but set the output for the following: output voltage = 270 volts, output range = 270 volts, current limit = 11.1 amps (3001i) or 18.5 amps (5001i). For step 7, the current limit value can be set to 9 amps.

In the unlikely event the power source does not pass the functional test, refer to the calibration procedure on page 6-1 or call California Instrument's customer satisfaction department for further assistance.

Table 2: System Interface Connector (J22)

J22	Description
1	Analog Common
2	Not used
3	Analog Common
4	Not used
5	CT Common, Current Transformer Common
6	Not used
7	Analog Common
8	Not used
9	Not used
10	$\overline{\text{OVR TEMP}}$ Overtemperature indication
11	$\overline{\text{CNF}}$, Output relay
12	Not used
13	FLT A, Phase A current limit fault
14	F STB LO, Function Sync output LO
15	EX SYNC LO, External Sync input LO
16	No connection
17	No connection
18	No connection
19	Not used
20	MR A, Phase A amplifier input signal
21	Not used
22	CS A, Phase A current sum
23	Not used
24	OS A, Oscillator Phase A output
25	Not used
26	CL A, Phase A DC current limit
27	D COM, Digital Common
28	$\overline{\text{RNG HI}}$, High Voltage range
29	
30	Not used
31	TRIGGER OUTPUT
32	EX SYNC HI, External Sync input HI
36	REMOTE SHUTDOWN

J22-1	ANALOG COMMON: This is the common for all analog signals on the connector.
J22-3	ANALOG COMMON: See J22-1.
J22-5	CT COMMON:
J22-7	ANALOG COMMON: See J22-1.
J22-10	$\overline{\text{OVR TEMP}}$: A logic low output to indicate an overtemperature condition. Make no connection to the pin.
J22-11	$\overline{\text{CNF}}$: Output relay control indication. This is an output logic line that indicates the state of the output relay. A logic low indicates the output relay is open. Make no connection to the pin.
J22-13	FLT A: Make no connections.
J22-14	F STB LO: Function Sync Low signal. This is the emitter lead of an optically isolated NPN transistor. The internal power controller turns this transistor on to indicate a change of programmed values.
J22-15	EX SYNC LO: External Sync Low signal. This is the ground return for the TTL external sync input. It connects to the cathode of an LED at the input of an optocoupler. Refer to J22-32.
J22-16	No connection.
J22-17	No connection.
J22-18	No connection.
J22-20	MR A: This is the input signal to the phase A amplifier from the internal oscillator drive signal. Do not make any connection to this pin except for troubleshooting.
J22-22	CS A: Current sum for the phase A output. Make no connection to this pin.
J22-24	OS A: This is the output from the internal phase A oscillator. Use this pin as an input if an oscillator is not installed. 5.0 VRMS on this pin will generate a full-scale output voltage.
J22-26	CL A: A DC level from the oscillator used to set the current limit for phase A. Make no connection to the pin.
J22-27	D COM: Digital common.
J22-28	$\overline{\text{RNG HI}}$: A logic output from the internal oscillator to control the ramp relays. A logic low on this pin indicates the high voltage range. If the power system is used without an oscillator, this pin is a logic input.
J22-29	Make no connection.
J22-31	TRIGGER OUTPUT: 400µs high pulse for voltage or frequency change. Isolated output that requires a pull-up resistor, 22KΩ, to ± 5 VDC.

J22-32 EX SYNC HI: External High signal. This is an input that can be used to synchronize the outputs of the AC Power System. This input requires a logic high level of at least +4.5 VDC at 5 mA. The input should have a duty cycle 50 ±30%. J22-15 is the common input. The External Sync input is optically isolated. It must also be enabled from the SNC screen.

J22-36 REMOTE SHUTDOWN: This is a logic input that can be used to remove the programmed output voltage. A logic low on this pin will cause the output voltages to be programmed to 0.0 volts and the output relays to open. A logic high will cause the programmed output voltage to be restored at the output terminals. A contact closure between this pin and J22-27 (D COM) will simulate a logic low state.

Figure 3-3: Functional Test Setup

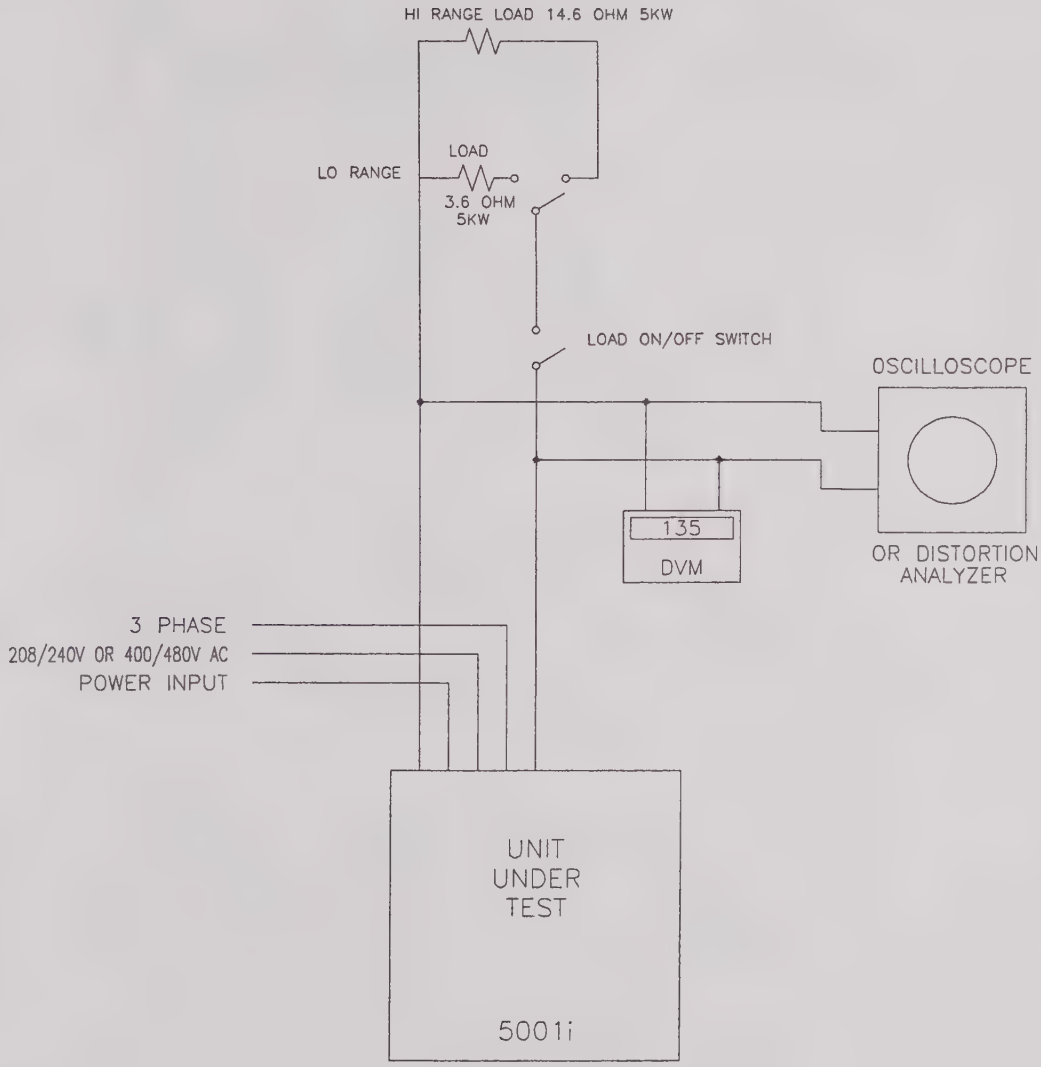


Figure 3-4: Three Phase 15000 VA System

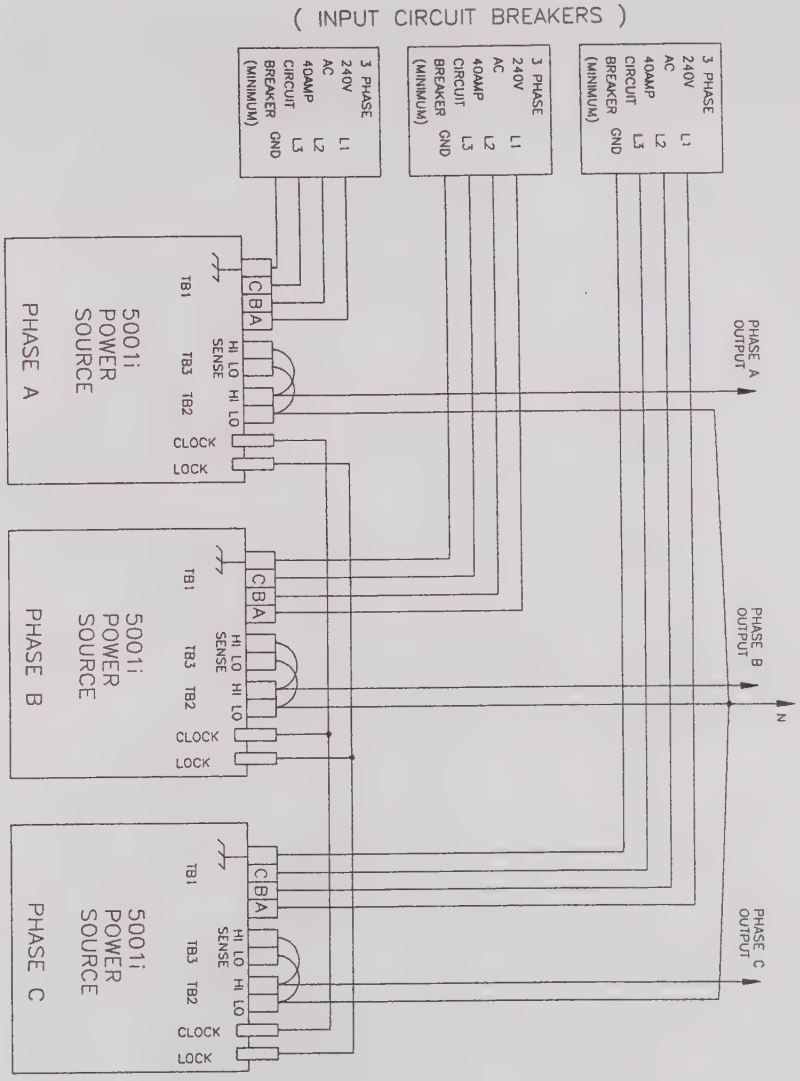
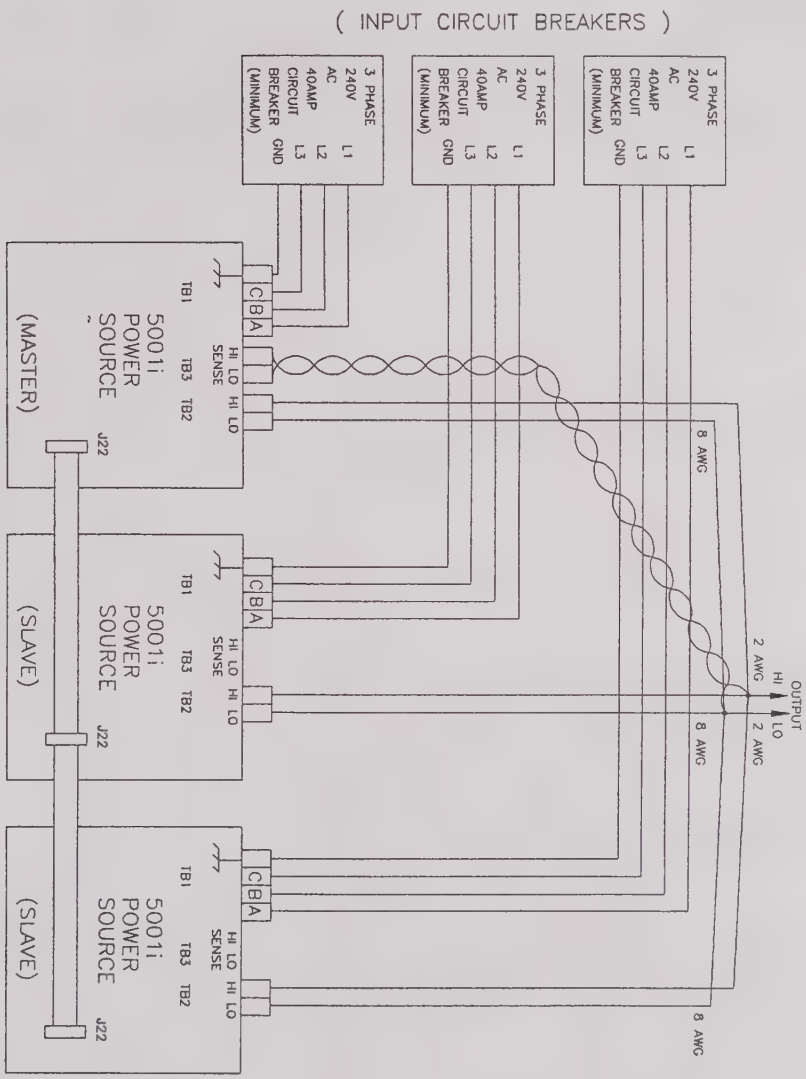


Figure 3-5: Single Phase 15000 VA System



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4. Front panel operation

4.1 Front panel guided tour

The front panel can be divided in a small number of functional areas:

- Main circuit breaker
- Status Indicator lights
- Shuttle knob.
- LCD display

- FUNCTION keypad
- DATA ENTRY keypad

4.1.1 Mains circuit breaker

The circuit breaker located on the bottom left side of the front panel disconnects the AC source from the mains input. It will automatically trip when the input current rating of the i-Series unit is exceeded due to some component failure. Its contrasting black color and large size throw bar make it easy to locate in case of an emergency.

4.1.2 Status Indicator lights

Four LED status indicators are located directly above the mains circuit breaker. These LED's correspond to the following conditions:

REMOTE	The REMOTE LED indicates that the unit is in remote control mode. If the IEEE-488 interface is used, this indicator will be asserted whenever the REM line (REMOTE ENABLE) line is asserted by the IEEE controller. If the RS232C interface is used, the REMOTE state can be enabled by the controller using the SYST:REM command. Any time the REMOTE LED is lit, the front panel of the i-Series unit is disabled. There is no LOCAL button that allows the user to regain control of the front panel.
OVERLOAD	The OVERLOAD LED indicates an output overload condition. This condition can be controlled by setting the current limit value in the PROGRAM menu. Removing the load using the OUTPUT ON/OFF button will recover from an overload condition.
OVER TEMPERATURE	The OVER TEMPERATURE LED indicates an overheating problem inside the i-Series unit. This is an abnormal condition which will cause the unit to shut off. Check the air flow exhaust at the rear of the unit to make sure it is not obstructed.

4.1.3 The Shuttle knob

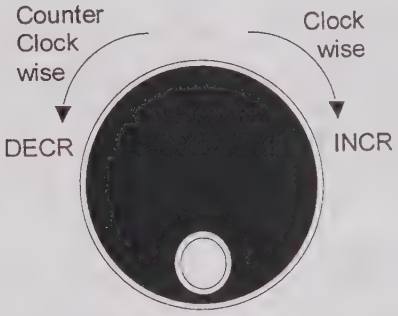


Figure 4-1: Shuttle Knob

The shuttle knob is located to the right of the LCD screen and is used to change setup parameters. Note that it cannot be used to move the cursor position between menu fields. Use the UP and DOWN arrow keys in the FUNCTION keypad for this.
The shuttle knob can operate in one of two distinct modes of operation:

MODE	DESCRIPTION
IMMEDIATE mode	Any time the ENTER key is pressed, the i Series returns to its normal mode of operation. In this mode, changes made with the shuttle knob or the data entry keypad will take immediate effect. The IMMEDIATE mode is useful for slewing output values such as voltage and frequency and observing the effect on the load.
SET mode	When the SET key located in the FUNCTION keypad is pressed, changes made with the shuttle to any output parameter will not take effect until the ENTER key is pressed. In this mode, any changes made to a setup menu will be blinking to indicate the pending change condition. This mode allows changes to be made to all output parameters and executing them all at once by pressing the ENTER key.

4.1.4 FUNCTION keypad

The function keypad provides access to all menus and measurement screens. The following keys are located in the FUNCTION keypad:

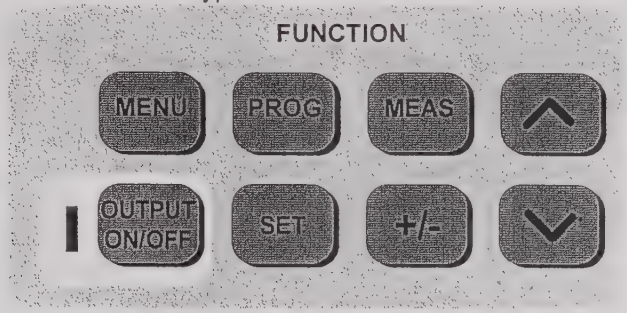


Figure 4-2: Function Keypad

KEY	DESCRIPTION
MENU	The top level menu is accessed by pressing the MENU key. Two shortcut keys are provided to provide direct access to the PROGRAM and MEASUREMENT screens as these are among the most frequently used screens. Thus instead of going through the main menu to reach the PROGRAM and MEASUREMENT screens, they can be accessed directly by pressing the PROG and MEAS keys respectively.
PROG	The PROG key is a shortcut to access the PROGRAM menu directly. The PROGRAM menu is on of the most frequently used menu. Thus instead of going through the main menu to reach the PROGRAM menu, it can be accessed directly by pressing the PROG key.
MEAS	The MEAS key is a shortcut to access the MEASUREMENT screen directly. The MEASUREMENT screen is one of the most frequently used screens. Thus instead of going through the main menu to reach the MEASUREMENT screen, it can be accessed directly by pressing the MEAS key.
CURSOR UP	The UP key moves the cursor position upwards one position to the previous available cursor position. If the present cursor position is at the top of the right hand column, the cursor is moved to the bottom position of the left hand column. If the present cursor is at the top of the right hand column, no action takes place. Figure 4-3 depicts the cursor movement through a two column menu.

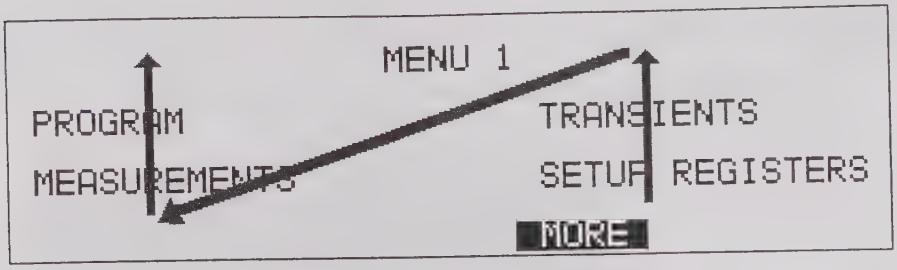


Figure 4-3: Cursor "up " Key Movement

CURSOR DOWN

The DOWN key moves the cursor position downwards one position to the next available cursor position. If the present cursor position is at the bottom of the left hand column, the cursor is moved to the top position of the right hand column. If the present cursor is at the bottom of the right hand column, no action takes place. Figure 4-4 depicts the cursor movement through a two column menu.

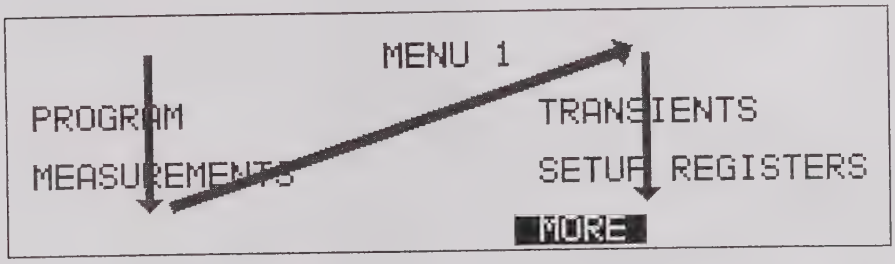


Figure 4-4: Cursor "down" Key Movement

OUTPUT ON/OFF

The OUTPUT ON/OFF key toggles the output relay on or off. The present of the output relay is reflected by the green LED located directly to the left of the OUTPUT ON/OFF key. If the green LED is lit, the output relay is enabled (closed) and the programmed output voltage is present at the output terminals. If the green LED is off, the output relay is open and both the Neutral and Line terminal of the output terminal block are disconnected from the power source. In this mode, the output is floating. The ON/OFF button provides a convenient way to disconnect the load without having to remove any wires.

SET

The SET key is used select the mode of operation of the shuttle. Refer to section 4.1.3 for details on its operation and the use of the SET key.

+/-

The +/- key can be used to toggle the sign for those parameters for which it is relevant. This is typically the output voltage when in DC mode of operation.

4.1.5 Data ENTRY keypad

The data ENTRY keypad is used to enter parameter values. Any decimal value can be entered, including a fractional part. The BACKSPACE key (<-) located to the left to the ENTER key can be used to erase one digit at a time. While parameter values are entered in a field, the field will blink to indicate the pending change of value. When the ENTER key is pressed, the entered values takes effect and the field stops blinking.
Note that only the field on which the cursor (reverse bar) is located can be changed.

Figure 4-5: Data Entry Keypad

4.1.6 LCD Display

The LCD display of the i Series AC power source provides information on instrument settings and also guides the user through the various menus. To ease reading of the displayed information, all screens are widely spaced. A sample of the main menu 1 screen that appears when the AC source is powered up is shown in Figure 4-6. Due to the amount of space available on each screen, some menus have been split into two parts, part 1 and part 2. The MORE selection located at the bottom right hand side provides access to menu choice at the same level that did not fit on a single screen. Thus, to access MENU 2, the cursor should be placed on the 'MORE' selection followed by pressing the 'ENTER' key.
The present cursor position is always shown with a inverse bar. The cursor is located on the 'MORE' selection in Figure 4-6. Pressing ENTER would cause MENU 2 to be displayed.
The cursor position can be moved by using the UP and DOWN keys located in the FUNCTION keypad.

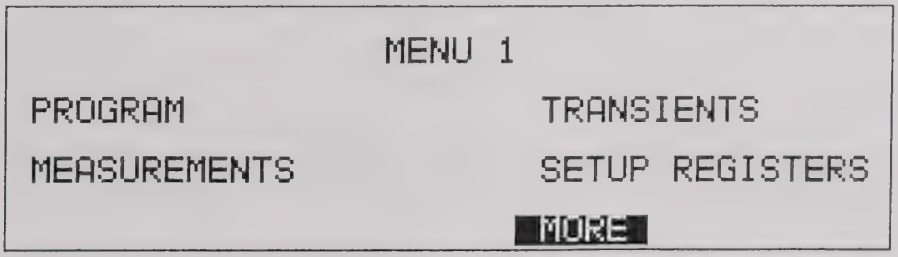


Figure 4-6: Main Menu 1 Screen

4.2 Menu structure

The i Series AC power source is operated by means of a collection of hierarchical menus that address the various aspects of setup, measurement and transient programming. This chapter provides an overview of the overall menu structure to help the user in finding his way around the instrument. The menu structure tree shown in Figure 4-8 can be used as a guide.

4.2.1 Menu Levels

The number of nested menu levels is limited to only three for virtually all areas of operation. The only exception to this rule is the MIL-STD 704D and RTCA-DO160C tests located in the APPLICATIONS menu. These tests require an additional nested level. The MIL-STD 704D and RTCA-DO160C are firmware options and may or may not be installed in your unit.
The menu levels are shown at the top of Figure 4-8 for reference. Level 1 is the main menu that appears when the i Series unit is first turned on or any time the MENU key is pressed.

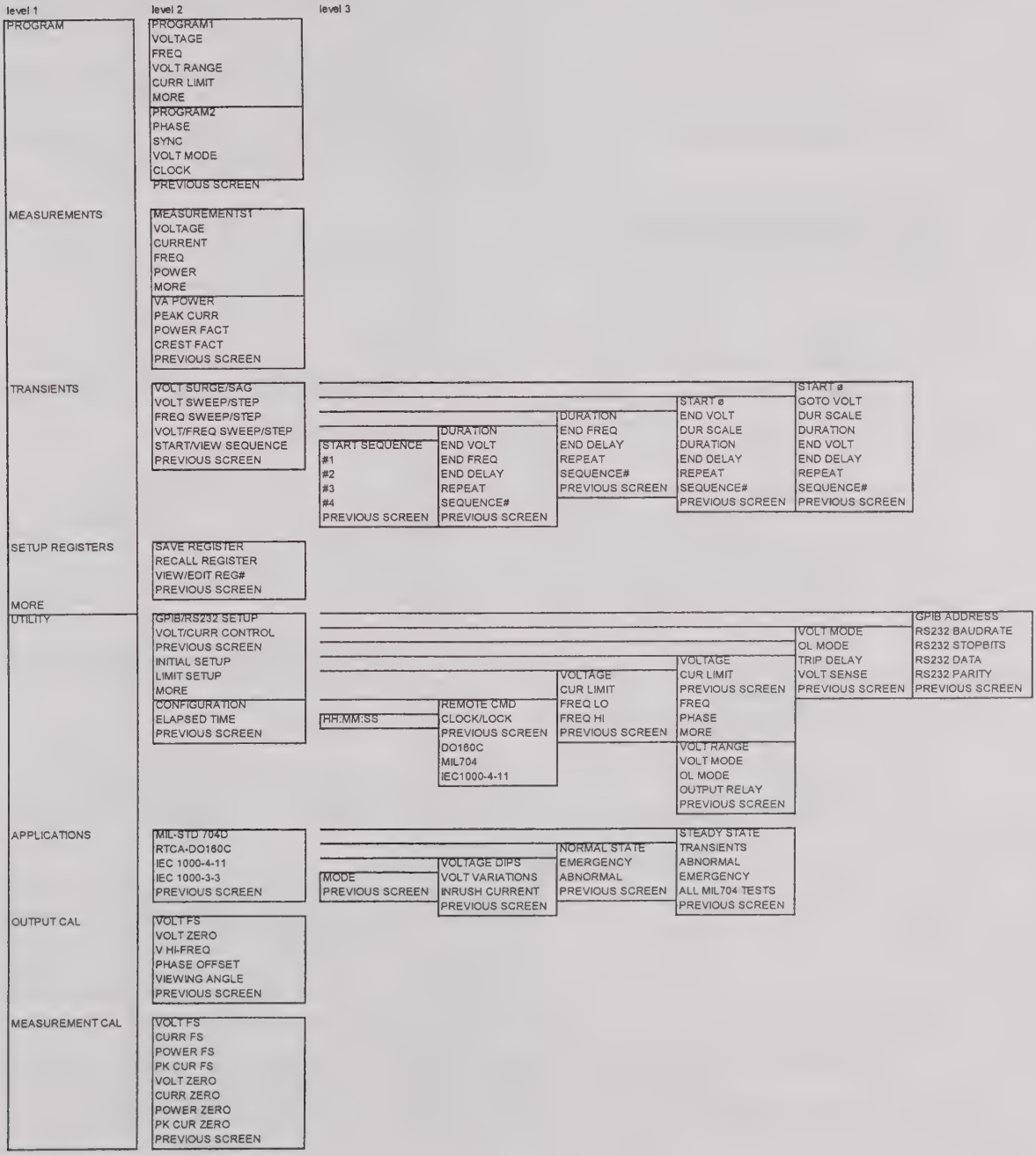
4.2.2 MAIN Menu

Figure 4-7: Main Menu 1 and 2

The top level menu is split in two parts, MENU 1 and MENU 2 to allows spacing between menu entries. MENU 2 can be reached from MENU 1 by selecting the MORE entry. The division of menu choices between the two screens is graphically illustrated in Figure 4-8 by the box in level 1. Each box represents one screen. The division is immediately following the MORE entry.
The top level menu offers the following level 2 menu choices:

Entry	Description
PROGRAM	The PROGRAM menu allows output parameters the be changed.
MEASUREMENTS	The MEASUREMENT screens are not menus in that no user entries are required. The MEASUREMENT screens show up to four output measurements at a time.
TRANSIENTS	The TRANSIENTS menu allows output transients to be programmed.
SETUP REGISTERS	The SETUP REGISTERS menu allows complete instrument settings or transient list programs to be saved to non volatile memory.
MORE	The MORE selection causes the second part of the MENU screen to be displayed. (MENU 2)
UTILITY	The UTILITY menu provides access to less commonly used setup screen such as those for the GPIB and RS232C interface settings, initial startup values etc.

Figure 4-8: i Series Structure Menu



Entry	Description
APPLICATIONS	The APPLICATIONS menu provides access to optionally installed firmware options that address specific applications. There may be no entries in the APPLICATIONS menu if no options are installed.
OUTPUT CAL	The OUTPUT CAL menu allows the output of the i Series AC source to be calibrated.
MEASUREMENT CAL	The MEASUREMENT CAL screen allows the measurement functions of the i-Series AC source to be calibrated.

4.2.2.1 PROGRAM Menu

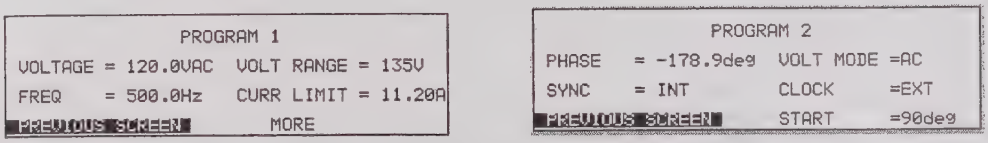

PROGRAM 1
VOLTAGE = 120.0VAC VOLT RANGE = 135V
FREQ = 500.0Hz CURR LIMIT = 11.20A
PREVIOUS SCREEN MORE
PROGRAM 2
PHASE = -178.9deg VOLT MODE =AC
SYNC = INT CLOCK =EXT
PREVIOUS SCREEN START =90deg

Figure 4-9: Program Menu

The PROGRAM menu is shown in Figure 4-9 it can be reached in one of two ways:
1. by selecting the PROGRAM entry in the MENU menu and pressing the ENTER key
2. by pressing the PROG key in the FUNCTION keypad

The PROGRAM menu is used to change output parameters. The most commonly used parameters are all located in PROGRAM 1. The PREVIOUS SCREEN entry , when selected, will return the user to the most recently selected menu. This is normally the MENU menu unless the PROGRAM menu was selected using the PROG key on the FUNCTION keypad. Less frequently used parameters are located in PROGRAM 2 which can be reached from PROGRAM 1 using the MORE selection.

The following choices are available in the PROGRAM menu:

Entry	Description
VOLTAGE	Programs the output voltage in rms. when in AC mode or absolute volt when in DC mode. In DC mode, negative values can be entered.
FREQ	Programs the output frequency when in AC mode. If the unit is in DC mode, the value for FREQ will be set to DC and cannot be changed until AC mode is selected. When in AC mode, the frequency can be changed from 16 Hz to 500 Hz. Values entered that fall outside this range will generate a -200 RANGE ERROR and will not be accepted.
VOLT RANGE	Selects 135V or 270V voltage range. The actual range values may be different depending on the configuration. The value of this field can only be changed with the shuttle.

CURR LIMIT	Sets the current limit value for the current detection system. When the load current value exceeds the set current limit, a fault condition is generated. The actual response of the AC Source to a current limit fault is determined by the protection mode selected in the CONFIGURATION menu. (CC = Constant Current, CV = Constant Voltage).
PHASE	Selects the phase angle between the external clock and the output of the AC source. If the clock source is internal, this parameter has no effect.
SYNC	Selects the synchronization mode. When INT (internal) is selected, the AC source's internal clock oscillator is free running. When EXT (external) is selected, the AC source clock is synchronized with an externally provided SYNC signal.
VOLT MODE	Selects the output voltage mode. AC for AC mode, DC for DC mode. In DC mode, no frequency selection is possible and all maximum current and power ratings are divided by two.
CLOCK	Selects internal or external clock source. The i Series uses an open air crystal timebase with an accuracy of 100 ppm. To improve out frequency stability and accuracy, an external clock generator may be used.
STARTø	Selects the starting phase angle for external clock mode operation. When external clock mode is selected, the phase angle of the AC source output is offset with respect to the external clock input signal by the value entered in this field.

4.2.2.2 MEASUREMENTS Screen

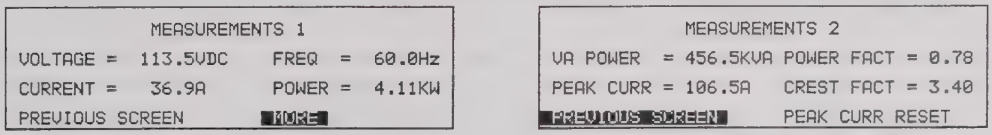

MEASUREMENTS 1
VOLTAGE = 113.5VDC FREQ = 60.0Hz
CURRENT = 36.9A POWER = 4.11KW
PREVIOUS SCREEN MORE
MEASUREMENTS 2
VA POWER = 456.5KVA POWER FACT = 0.78
PEAK CURR = 106.5A CREST FACT = 3.40
PREVIOUS SCREEN PEAK CURR RESET

Figure 4-10: Measurements Screen

The two Measurement screens are not menus in that no changes can be made anywhere. These two screens provide load parameter readouts. The following parameters are available :

Entry	Description
VOLTAGE	When in AC mode, this value is the true rms. output voltage measured at the output sense lines. In DC mode, the voltage is the DC voltage including polarity.
CURRENT	When in AC mode, this value is the true rms. output current drawn by the load. In DC mode, the current is the DC current including polarity
FREQ	When in AC mode, the output frequency is measured at the sense lines. When in DC mode, this value always reads 0 Hz.
POWER	In both AC and DC mode, this value is the real rms. power consumed by the load.

VA POWER	In AC mode, this value is the apparent rms. power consumed by the load. In DC mode, this value is always the same as the POWER readout.
PEAK CURR	This readout reflects the peak current value detected at the output. To measure inrush current for a unit under test, open the output relay and reset the peak current value using the PEAK CURR RESET entry. Then program the output voltage and frequency and turn on the output relay. The peak current measurement will continuously track the maximum current value detected until reset.
POWER FACTOR	This readout shows the power factor of the load.
CREST FACTOR	This readout displays the ratio between peak current and rms current.

4.2.2.3 SETUP REGISTERS Menu

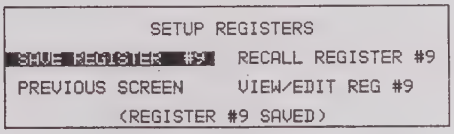


Figure 4-11: Setup Registers Menu

The SETUP REGISTERS menu allows the user to store and recall complete instrument setups, including transient program lists. A total of 12 non volatile setup registers is available, numbered sequentially from 1 through 12.
The following entries can be found in the SETUP REGISTERS menu:

Entry	Description
SAVE REGISTER	Save present instrument setups to a register number selected by the user. The numeric data entry keypad should be used to enter a number between 0 and 7. Once the ENTER key is pressed, all settings are saved. A message will appear at the bottom of the screen to confirm the save operation.
RECALL REGISTER	Recall instrument setups from a register number selected by the user. The numeric data entry keypad should be used to enter a number between 0 and 7. Once the ENTER key is pressed, all settings are recalled. A message will appear at the bottom of the screen to confirm the recall operation.
VIEW/EDIT REGISTER	The View/Edit entry can be used to display the contents of a setup register before it is recalled. After the user enters a register number to view or edit and presses the ENTER key, the PROGRAM screen will appear. All parameters that will be changed by recalling the register will be blinking. If ENTER is pressed again, the register will be recalled and the new values take effect. To edit the register content, change all parameters that need to be changed. Pressing ENTER will save the new values and make them active.

4.2.2.4 TRANSIENTS Menu

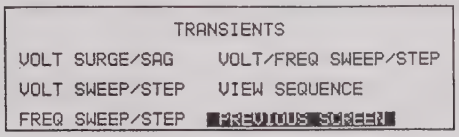


Figure 4-12: Transients Menu

The transient menu provides access to the transient list data. The i Series has a transient list of up to 32 data points. This is represented by 32 transient step numbers from 1 through 32. From the Transient menu, the desired transient step type can be selected. Based on the user's choice, the relevant transient type submenu will be shown. The four available submenu's can be found in Figure 4-12. The START/EDIT SEQUENCE submenu allows the user to review and change any transient step or execute the transient list. When executing a transient list, transient steps are executed in a ascending numerical order. Steps that are not defined are skipped.
The following entries can be found in the TRANSIENTS menu:

Entry	Description
VOLT SURGE/SAG	Voltage surges and sag are temporary changes in amplitude. The output voltage will change from its present value to a user specified value for a specified duration. (Sag if the value is lower, surge if the value is higher.) After this period has expired, the output voltage returns to a user specified end value. This value may or may not be the same as the value present prior to the start of the sag or surge.
VOLT SWEEP/STEP	Voltage sweeps cause the output voltage to change from the present value to a user specified end value at a specified rate of change. A voltage step on the other hand is an instantaneous change in output voltage. The new value will be held for the duration period specified by the user. The final output voltage value of a sweep and a step transient step should be different than the value at the start of the transient step or no change in output value will occur.
FREQ SWEEP/STEP	This transient type is identical to a voltage sweep/step. Refer to the previous paragraph.
VOLT/FREQ SWEEP/STEP	This transient type combined the previous two types into a single step. The effect is that of slewing or changing the output voltage and frequency simultaneously. Note: While this transient is programmed as a single transient step, two list entries are required to store this information. As such, every VOLT/FREQ SWEEP/STEP used will consume two list entries at a time.
START/VIEW SEQUENCE	This entry allows the user to switch to the transient execution menu. This menu provides a list of all available transient list steps and their sequence numbers. From this menu, transient list execution can be started.

The same menu can be used to view or edit any available transient list step or erase a step using the backspace key.

4.2.2.5 UTILITY Menu

Figure 4-13: Utility Menu

The UTILITY menu provides access to the less frequency used setup items. Their is no logical connection between the various entries in the UTILITY menu other than there is no other place to put them. The following entries can be found in the UTILITY menu:

Entry	Description
GPIB/RS232 SETUP	This entry provides access to the setup parameters for either the IEEE-488 bus or the RS232C bus. All parameters are saved in non-volatile memory so their is rarely a need to change these values.
VOLT/CURR CONTROL	The voltage and current control menu can be used to select the voltage sense source and current limit method used by the AC source. Voltage sense can be internal or external. For best output voltage regulation, select external sense and make sure to connect the sense lines to the load to compensate for voltage drops in the load cables. The two current limit choices available are Constant Voltage and Constant Current. Constant Voltage mode will maintain the set voltage at the output until the load current exceeds the current limit set at which time the voltage will be dropped to zero. This effectively shuts off the AC source in case of an overload condition. This mode has a user programmable trip delay which is located in the same menu. Constant Current mode will maintain the load current at the maximum level set by the current limit value, even if the maximum power level is exceeded. This is done by reducing the voltage as needed. As such, the voltage will be reduces from the set level down to zero depending on the load requirement. This mode is useful for starting up inductive or capacitive loads that may require a high inrush current. The trip delay has no effect in this mode of current limiting.
INITIAL SETUP	The initial setup menu can be used to determine the AC source settings at power up. ***CAUTION: The initial setup can be used to power up the AC source with the output on and a high voltage present at the output.*** For normal situations, this is not recommended due to the potential danger to operators. It is recommended that the initial voltage be set low and / or the output relay be programmed to OFF for most situations.

LIMIT SETUP	The Limit menu shows the frequency, voltage and current limit capabilities of the AC source. Any attempt to program the output beyond these limits will result in a "-222 Data Out of Range error". Note that these limits are hardware determined and cannot be changed by the user. They are shown for reference only.
CONFIGURATION	The Configuration menu shows the installed options. This screen is for reference only and no fields can be changed by the user.
ELAPSED TIME	The elapsed time screen, when selected from the UTILITY menu will appear for about 3 seconds. The elapsed time shown is the cumulative amount of time the power source has been on from its inception. This value is read only and cannot be changed by the user.

4.2.2.6 APPLICATIONS Menu

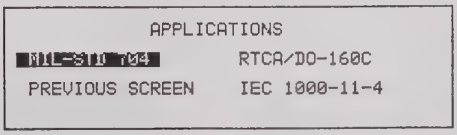


Figure 4-14: Applications Menu

The APPLICATIONS menu provides access to the optional application specific pre-programmed test sequences. Since these test sequences are optional, this menu can have no choices if none of the options are installed. The following entries may be found in the APPLICATIONS menu:

Entry	Description
MIL-STD 704	Test sequence for MIL standard 704 AC and DC tests.
RTCA/DO-160	Test sequence for RTCA DO160 commercial aviation AC and DC tests.
IEC-1000-4-11	Test sequences for IEC 1000-4-11 Voltage Dips and Variations test standard.

4.2.2.7 OUTPUT CAL Menu

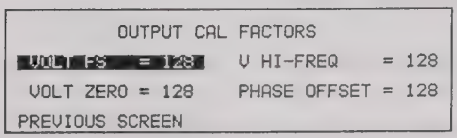


Figure 4-15: OUTPUT CAL Menu

The OUTPUT CAL menu provides access to the output calibration parameters. These parameters are password protected and can only be changed after the calibration password has been entered. Refer to the i Series user manual for information on calibration procedures.

4.2.2.8 MEASUREMENT CAL Menu

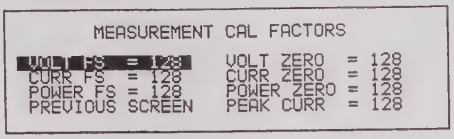


Figure 4-16: MEASUREMENT CAL Menu

The MEASUREMENT CAL menu provides access to the measurement calibration parameters. These parameters are password protected and can only be changed after the calibration password has been entered. Refer to the i Series user manual for information on calibration procedures.

4.3 How to...

This chapter covers some common tasks that are often performed with an AC power source. These examples are written in a How to... format and provide step by step instructions on how to set up the i Series source for a specific task.

4.3.1 Set the output

Output parameters are all set from the PROGRAM screen.

1. Use the MENU key and select the PROGRAM entry.
2. Press the ENTER key to bring up the PROGRAM menu.

or

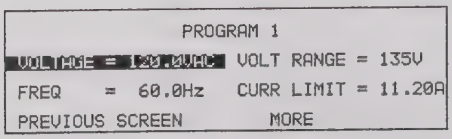
1. Use the PROG key to directly bring up the PROGRAM menu.

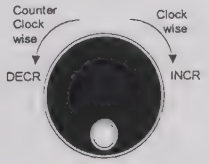
There are two methods for programming output parameters:

IMMEDIATE mode
SET mode

4.3.1.1 Slewing output values with the Knob in IMMEDIATE mode

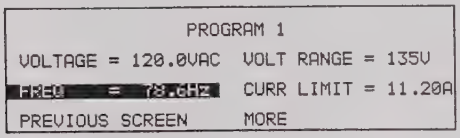
The default mode of operation is an immediate mode in which changes to output parameters made with the knob or the entry keypad are immediately reflected at the output.
To change the output voltage

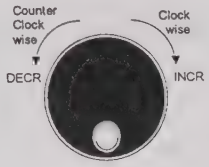




1. Place the cursor on the VOLTAGE entry
2. Rotate the knob clock wise to increase the value, counter clockwise to decrease the value

These changes take effect immediately.
To change the output frequency



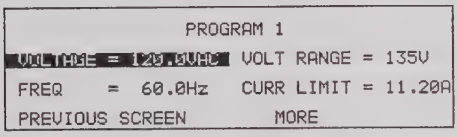


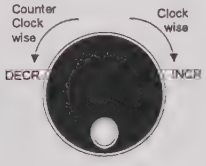
1. Place the cursor on the FREQ entry
2. Rotate the knob clock wise to increase the value, counter clockwise to decrease the value

These changes take effect immediately.

4.3.1.2 Change output values with the Knob in SET mode

The SET mode of operation is a mode in which changes to output parameters made with the knob or the entry keypad are do not affect the output until the ENTER key is pressed. The AC source is put in this SET mode by pressing the SET key.
To change the output voltage





1. Press the SET key
2. Place the cursor on the VOLTAGE entry
3. Rotate the knob clock wise to increase the value, counter clockwise to decrease the value
4. The VOLTAGE field will be blinking to indicate a change in settings but the output remains unchanged.
5. Place the cursor on the FREQ entry
6. Rotate the knob clock wise to increase the value, counter clockwise to decrease the value
7. The FREQ field will be blinking to indicate a change in settings but the output remains unchanged.
8. Press the ENTER key.

Both new voltage and frequency output values are now present at the output. The unit has returned to immediate mode of operation until the SET key is pressed again.

4.3.1.3 Change output value with the decimal keypad

Figure 4-17: Entering Value from Decimal Keypad

The decimal keypad can be used at any time in lieu of the shuttle knob to change output parameters. Direct data entry is often faster to effect large changes in values than using the shuttle knob. Note that pressing the ENTER key while in SET mode of operation will cause the AC source to revert back to IMMEDIATE mode. Thus, to change all parameters in SET mode, enter a value for each field and then proceed to the next field without pressing the ENTER key.

Note :	**The BACKSPACE (←) key can be used to erase one digit at a time if you make a data entry error.**

4.3.2 Set power up defaults

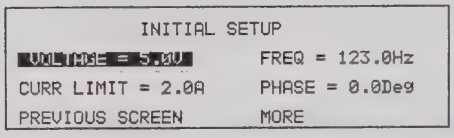


Figure 4-18: Initial Setup Menu

Any time the AC source is powered up, the output will reflect the values stored as the INITIAL setup values. This allows the unit to be powered up in a known state at all times. The INITIAL values can be set in the INITIAL SETUP menu.
To access the INITIAL SETUP menu, proceed as follows:

1. Press the MENU key
2. Move the cursor down to the MORE field
3. Press the ENTER key
4. Move the cursor down to the INITIAL SETUP entry
5. Press the ENTER key
6. Move the cursor to the field you wish to change.
7. Enter a new value with the shuttle knob or the decimal keypad
8. Press ENTER to confirm your entry

9. Repeat steps 6 through 8 for all parameters. You can access additional initial setting parameters by selecting the MORE entry and pressing ENTER.
10. Turn the unit off
11. Wait a few seconds and turn the unit back on.
12. Press the PROG key and verify that the INITIAL settings are present in the PROGRAM menu.

CAUTION: **The initial setup can be used to power up the AC source with the output on and a high voltage present at the output. For normal situations, this is not recommended due to the potential danger to the operator. It is recommended that the initial voltage be set low and / or the output relay be programmed to OFF for most situations.**

4.3.3 View measurements

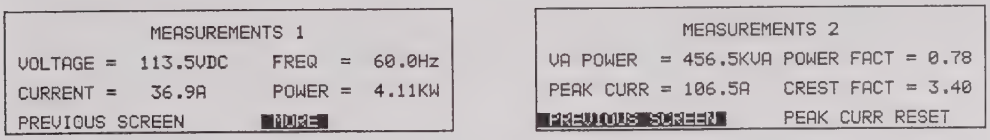

MEASUREMENTS 1
VOLTAGE = 113.5VDC FREQ = 60.0Hz
CURRENT = 36.9A POWER = 4.11KW
PREVIOUS SCREEN MORE
MEASUREMENTS 2
VA POWER = 456.5KVA POWER FACT = 0.78
PEAK CURR = 106.5A CREST FACT = 3.40
PREVIOUS SCREEN PEAK CURR RESET

Figure 4-19: Measurements Screen

The MEASUREMENTS screen can be called up in one of two ways :

1. Press the MENU key to select the MAIN menu.
2. Scroll down to the MEASUREMENTS entry using the Up and Down cursor keys.
3. Press the ENTER key to bring up the MEASUREMENTS menu.

or

1. Use the MEAS key to directly bring up the MEASUREMENTS menu.

Note that the measurement menu is broken down in two parts, MEASUREMENTS 1 and MEASUREMENTS 2. The second screen can be selected by moving the cursor to the MORE entry and pressing the ENTER key.

4.3.3.1 Measure inrush current

The peak current reading will always show the maximum peak current value found so far. To determine the inrush current of a load, proceed as follows:

1. Turn off the output relay with the OUTPUT ON/OFF switch.
2. Move the cursor in the MEASUREMENTS 2 screen to the PEAK CURR RESET field at the end of the screen.
3. Press the ENTER key to reset the PEAK CURR reading.
4. Turn the output on with the OUTPUT ON/OFF switch.
5. Read the inrush current value in the PEAK CURR field.

4.4 Transient programming

The TRANSIENT screen can be called from the MAIN menu screen:

1. Press the MENU key to select the MAIN menu
2. Scroll to the TRANSIENTS entry using the up and down cursor keys.
3. Press the ENTER key to bring up the TRANSIENTS menu.

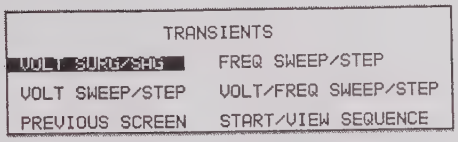


Figure 4-20: Transient Menu

The TRANSIENT screen shown in
9 has the following selections:

1. VOLT SURG/SAG
2. VOLT SWEEP/STEP
3. FREQ SWEEP/STEP
4. FREQ SWEEP/STEP
5. VOLT/FREQ SWEEP/STEP
6. START/VIEW SEQUENCE

Selection one through five will allow the user to setup the transient type parameters. Selection six will show a list of available transient events presently in memory. The same screen will allow the transient program to be executed.

4.4.1 Voltage surge and sags

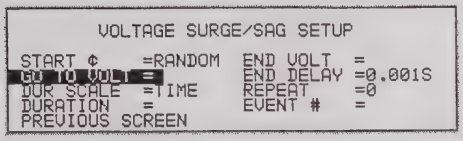


Figure 4-21: Surge sag Screen

The VOLTAGE SURGE AND SAGS screen shown in Figure 4-21 can be reached from the TRANSIENT screen as follows:

1. Scroll to the VOLT SURG/SAG entry using the up and down cursor keys.
2. Press the ENTER key to bring up the VOLT SURG/SAG screen.

The VOLT SURG/SAG screen has several data fields. All data fields that are blank to the right to the equal sign, must be filled or an error message will occur when trying to leave this screen. The EVENT # is the last data field to be filled. Entering the event data field will cause the display to return to the TRANSIENT screen where a new selection can be made.

The VOLT/SURGE/SAG screen has the following fields:

1. START ø

This field will show the start phase angle of the voltage transient in degrees. Only one start phase angle per transient sequence is allowed. The start phase angle must be in the first transient event in the list. The start phase angle is not valid for DC transient.

2. GO TO VOLT

This field will set the voltage level during the transient duration in volts

3. DUR SCALE

Duration scale default is time in seconds. Use the shuttle knob to select CYCLES if desired. Note that durations expressed in cycles may cause rounding errors if the period of the selected frequency setting is not an integer number of milliseconds. Thus, for 50 Hz applications, no rounding errors occur but for 60 Hz, the 16.666666666666..... ms period will cause a rounding error when converted. The Duration scale selection affects both the DURATION and END DELAY parameters.

4. DURATION

Duration is the time the output voltage level will dwell at the GO TO VOLT level. The DUR SCALE defines the time scale of this parameter in CYCLES or SECONDS

4. END VOLT

This is the output voltage level at the end of the transient EVENT and after a time specified by the DURATION

5. END DELAY

This is the time delay the voltage level will stay at the END VOLT level before it proceeds with the next transient event or completes the transient.

6. REPEAT

This is the number of times the SURGE/SAG transient event will repeat before it will proceed to the next event or exit the transient program. Note that the number of times the transient event is generated is equal to the REPEAT + 1. Leave this value at zero if only one execution of this event in the list is required.

7. EVENT #

This must be the last item in the TRANSIENT EDIT screen. All data fields must be entered before inserting the EVENT #. The EVENT # takes value from 1 to 99. The EVENT # defines the order of execution of the transient EVENTs in a multiple event transient. It is a good practice to enter spaced EVENT # to allow insertion of an EVENT later if needed. (For example, space then by 5) Entry of a sequence EVENT# number will cause the display to return to the TRANSIENT screen.

4.4.2 Voltage sweep/step

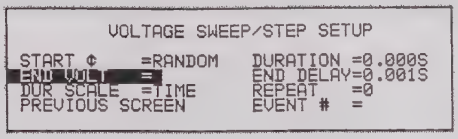


Figure 4-22: Voltage Sweep/Step Screen

The VOLTAGE SWEEP AND STEP screen shown in Figure 4-22 can be reached from the TRANSIENT screen as follows:

1. Scroll to the VOLT SWEEP/STEP entry using the up and down keys.
2. Press the ENTER key to bring up the VOLTAGE SWEEP/STEP screen.

The VOLTAGE SWEEP/STEP screen has several data fields. All data fields that are blank to the right to the equal sign, must be filled or an error message will occur when trying to leave this screen. The EVENT # is the last data field to be filled. Entering the event data field will cause the display to return to the TRANSIENT screen where a new selection can be made.

The VOLTAGE SWEEP/STEP screen has the following fields:

1. START ⌀

This field will show the start phase angle of the voltage transient in degrees. Only one start phase angle per transient sequence is allowed. The start phase angle must be in the first transient event in the list. The start phase angle is not valid for DC transient.

2. END VOLT

This is the output voltage level at the end of the transient event in volts.

3. DUR SCALE

Duration scale default is time in seconds. Use the shuttle knob to select CYCLES if desired. Note that durations expressed in cycles may cause rounding errors if the period of the selected frequency setting is not an integer number of milliseconds. Thus, for 50 Hz applications, no rounding errors occur but for 60 Hz, the 16.666666666666..... ms period will cause a rounding error when converted. The Duration scale selection affects both the DURATION and END DELAY parameters.

4. DURATION

Duration is the time it will take for the output voltage to reach the END VOLT level. As such, "Duration" will define the slew rate of the output voltage for the event. A duration of 0 seconds will cause the output voltage to reach the end voltage immediately. The DUR SCALE defines the time parameter CYCLES or SECONDS

5. END DELAY

This is the time delay the voltage level will stay at END VOLT before it proceeds with the next transient event or completes the transient.

6. REPEAT

This is the number of times the VOLTAGE SWEEP/STEP transient event will repeat before it will proceed to the next event or exit the transient program. Note that the number of times the transient event is generated is equal to the REPEAT + 1. Leave this value at zero if only one execution of this event in the list is required.

7. EVENT #

This must be the last item in the TRANSIENT EDIT screen. All data fields must be entered before inserting the EVENT #. The EVENT # takes value from 1 to 99. The EVENT # defines the order of execution of the transient EVENTs in a multiple event transient. It is a good practice to enter spaced EVENT # to allow insertion of an EVENT later if needed. (For example, space then by 5) Entry of a sequence EVENT# number will cause the display to return to the TRANSIENT screen.

4.4.3 Frequency sweep/step

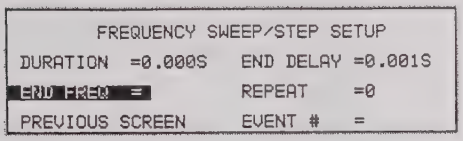


Figure 4-23: Frequency Sweep/Step Screen

The VOLTAGE SWEEP AND STEP SCREEN shown in Figure 4-23 can be reached from the TRANSIENT screen as follows:

1. Scroll to the FREQ SWEEP/STEP entry using the up and down cursor keys.
2. Press the ENTER key to bring up the FREQ SWEEP/STEP screen.

The FREQ SWEEP/STEP screen has several data fields. All data fields that are blank to the right to the equal sign, must be filled or an error message will occur when trying to leave this screen. The EVENT # is the last data field to be filled. Entering the event data field will cause the display to return to the TRANSIENT screen where a new selection can be made.

The FREQ SWEEP/STEP screen has the following fields:

1. DURATION

Duration is amount of the time the output frequency will take to reach the END FREQ level. Duration will define the slew rate of both the output frequency for the event. A duration of 0 seconds will cause the output frequency to reach the end frequency immediate.

2. END FREQ

This is the output frequency at the end of the transient event in Hz.

3. END DELAY

This is the time delay the frequency will stay at END FREQ before it proceeds with the next transient event or completes the transient.

4. REPEAT

This is the number of times the FREQUENCY SWEEP/STEP transient will repeat before it will proceed to the next event or exit the transient. The number of times the transient event is generated is equal to the REPEAT + 1. Leave this value at zero if only one execution of this event in the list is required.

5. EVENT #

This must be the last item in the TRANSIENT EDIT screen. All data fields must be entered before inserting the EVENT #. The EVENT # takes value from 1 to 99. The EVENT # defines the order of execution of the transient EVENTs in a multiple event transient. It is a good practice to enter spaced EVENT # to allow insertion of an EVENT later if needed. (For example, space then by 5) Entry of a sequence EVENT# number will cause the display to return to the TRANSIENT screen.

4.4.4 Volt/freq sweep/step

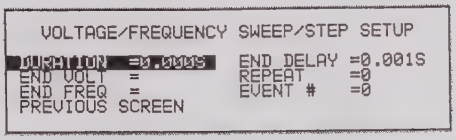


Figure 4-24: VOLT/FREQ SWEEP/STEP screen

The VOLT/FREQ SWEEP/STEP screen shown in Figure 4-24 can be reached from the TRANSIENT screen as follows:

1. Scroll to the VOLT/FREQ SWEEP/STEP entry using the up and down cursor keys.
2. Press the ENTER key to bring up the VOLT/FREQ SWEEP/STEP screen.

The VOLT/FREQ SWEEP/STEP screen has several data fields. All data fields that are blank to the right to the equal sign, must be filled or an error message will occur when trying to leave this screen. The EVENT # is the last data field to be filled. Entering the event data field will cause the display to return to the TRANSIENT screen where a new selection can be made.

The VOLT/FREQ SWEEP/STEP screen has the following fields:

1. DURATION

Duration is the amount of time the output voltage and frequency will take to reach the END FREQ and END VOLT levels. Duration will define the slew rate of the output voltage and frequency for the events. A duration of 0 seconds will cause the output voltage and frequency to reach the end frequency immediate.

2. END FREQ

This is the output frequency at the end of the transient event in Hz.

3. END VOLT

This is the output voltage at the end of the transient event in volts.

4. END DELAY

This is the time delay the output frequency and voltage will stay at END FREQ and END VOLT before it proceeds with the next transient event or completes the transient.

5. REPEAT

This is the number of times it will repeat the VOLTAGE/FREQUENCY SWEEP/STEP transient before it will proceed to the next event or exit the transient. The number of times the transient event is generated is equal to the REPEAT + 1. Leave this value at zero if only one execution of this event in the list is required.

6. EVENT #

This must be the last item in the TRANSIENT EDIT screen. All data fields must be entered before inserting the EVENT #. The EVENT # takes value from 1 to 99. The EVENT # defines the order of execution of the transient EVENTs in a multiple event transient. It is a good practice to enter spaced EVENT # to allow insertion of an EVENT later if needed. (For example, space then by 5) Entry of a sequence EVENT# number will cause the display to return to the TRANSIENT screen.

4.4.5 View and execute transients

Transient events can be viewed for further editing before execution. This can be accomplished form the START/VIEW SEQUENCE screen.

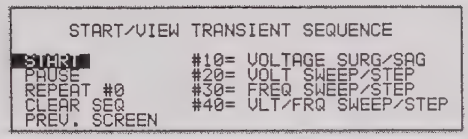


Figure 4-25: Start/view transient sequence

The START/VIEW SEQUENCE screen shown in Figure 4-25 can be reached from the TRANSIENT screen as follows:

1. Scroll to the START/VIEW SEQUENCE entry using the up and down cursor keys.
2. Press the ENTER key to bring up the START/VIEW SEQUENCE screen.

The START/VIEW SEQUENCE screen has the following data field:

1. START/ABORT

This field is used to start or abort the transient. Scroll down or up to the START entry using the up and down cursor keys. Press the ENTER key to start the transient. This field will become an ABORT when the transient is in progress. Press down the enter key will abort the transient immediate. The steady output voltage and frequency is the voltage and frequency level at the time of abort.

2. PAUSE/RESUME

This field is used to PAUSE the transient. This field is only active when the transient is in progress. To activate the PAUSE key, scroll down or up to the PAUSE entry using the up and down cursor keys. Press the ENTER key to pause the transient while the transient is in progress. The transient will pause immediately. Both voltage and frequency will stay at the last values before the pause. The field will indicate RESUME. Pressing the RESUME key will cause the transient to continue from the point at which it was paused.

3. REPEAT

This field will accept a number from 0 to 999,999. The REPEAT field will allow the transient sequence to run the number times entered plus one. Note this repeat is different from the repeat associated with each transient event. This is a global sequence repeat as opposed to an individual program event repeat. To select the REPEAT field, scroll to the REPEAT entry using the up and down cursor keys. Use the numeric key pad to enter the number desired.

4. CLEAR SEQ

This field will delete all transient events. Care must be taken to avoid accidental selection of this field. To select the CLEAR SEQ field, scroll to the CLEAR SEQ entry using the up and down cursor keys. To clear all events press the ENTER key.

5. VIEW TRANSIENT EVENTS

All fields on the right hand side of the display will show the events that make up the transients sequence or program. The transient events are sorted by their sequence numbers. Each field shows the event number followed by the event type. A maximum of five events can be visible on the screen. Scroll up or down to select an event that is not visible in the screen. To view an event scroll up or down to the event and press the ENTER key. Now you can view and edit the event.

6. CLEAR TRANSIENT EVENTS

Scroll to the transient event you want to delete using the up and down cursor keys. Use the back space key ← to delete the transient event.

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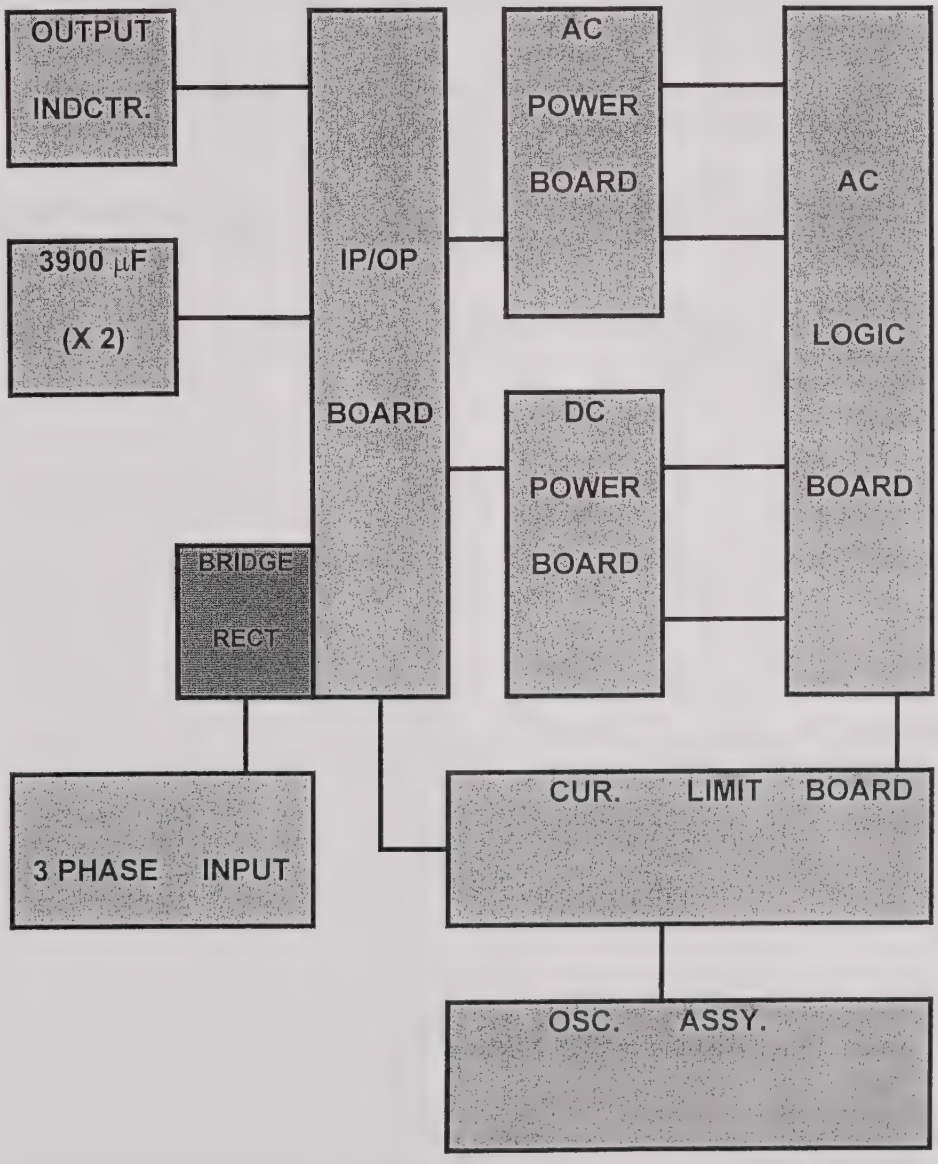
5. Principle of operation

5.1 General

An explanation of the circuits in the 3001i and 5001i is given in this section. Refer to Figure 5-1 for a block diagram of the system. Figure 5-6 shows the system interconnect.

Figure 5-1: AC Power System Block Diagram



5.2 Overall description

Three phase input power is routed in from the back panel through an EMI filter and the circuit breaker to the input bridge rectifier. The DC output from the bridge rectifier is smoothed by a small amount of capacitance in order to keep the input power factor as high as possible. This DC output supplies the converter on the DC power board.

The DC converter turns the unregulated rectified AC into a smoothed, isolated, tightly regulated DC supply. Also mounted on the DC power board is the auxiliary power supply. The aux. PS supplies low voltage logic level power to the control logic board, the oscillator board, the AC power board as well as the fan. The output of the DC converter is fed to two 3900 μF electrolytic capacitors on the I/O board. These capacitors also provide holdover storage energy to ride through line dropouts.

The AC power board takes the DC input and puts out isolated, direct coupled, AC power. The DC bus is regulated at 250 volts for the 135 VAC output and 400 volts for the 270 V AC output.

The oscillator assembly generates the sine wave signal and provides frequency and amplitude control. The current limit board in conjunction with the oscillator board provides the current limit function.

The assemblies are described in more detail in the following paragraphs. Refer to Figure 5-2 for an overall block diagram.

5.3 Oscillator assembly

The oscillator assembly consists of three printed circuit board assemblies connected by a ribbon cable. The oscillator generates the sine wave signal setting the frequency, amplitude and current limit level. It also senses the output voltage to provide closed loop control of the output.

5.3.1 Waveform board

This board assembly, A8, consists of the components for generating the input signal for the power amplifier. In addition, the waveform board contains the circuits for all measurements and remote sense. The clock and lock circuit for 3-phase operation is also on this board assembly.

The waveform board has several jumpers that are used to enable various option. Refer to the following table for the options. See Figure 5-2.

	JUMPER (+= in, - = out)									
	W1	**W2**	**W3**	**W4**	**W5**	**W6**	**W7**	**W8**	**W9**	**W10**
Standard, CLK & LK Master	+	-	-	+	-	+	+	-	-	+
CLK & LK Slave	+	-	-	-	+	-	-	+	+	-
External Modulation, % Program value	-	+	-	See above for CLK & LK Options						
External Modulation, ± 15VRMS	-	-	+	See above for CLK & LK Options						

5.3.2 Keyboard/ Display board

The keyboard/ display assembly is assembly A9. It is mounted to the front panel and holds the 21 rubber keys. It also has the LCD graphics display. A shaft encoder is mounted on the board that is used for a shuttle input.

5.3.3 CPU board

This assembly, A7, has the CPU and all memory devices. It also has a nonvolatile RAM for storage of calibration, configuration and setup data. The RAM has a 10 year life expectancy.

5.3.4 GPIB/ RS232 board

This board assembly is identified as A10. It has the IEEE 488 and RS232 transceivers. It also has optocouplers for both interfaces.

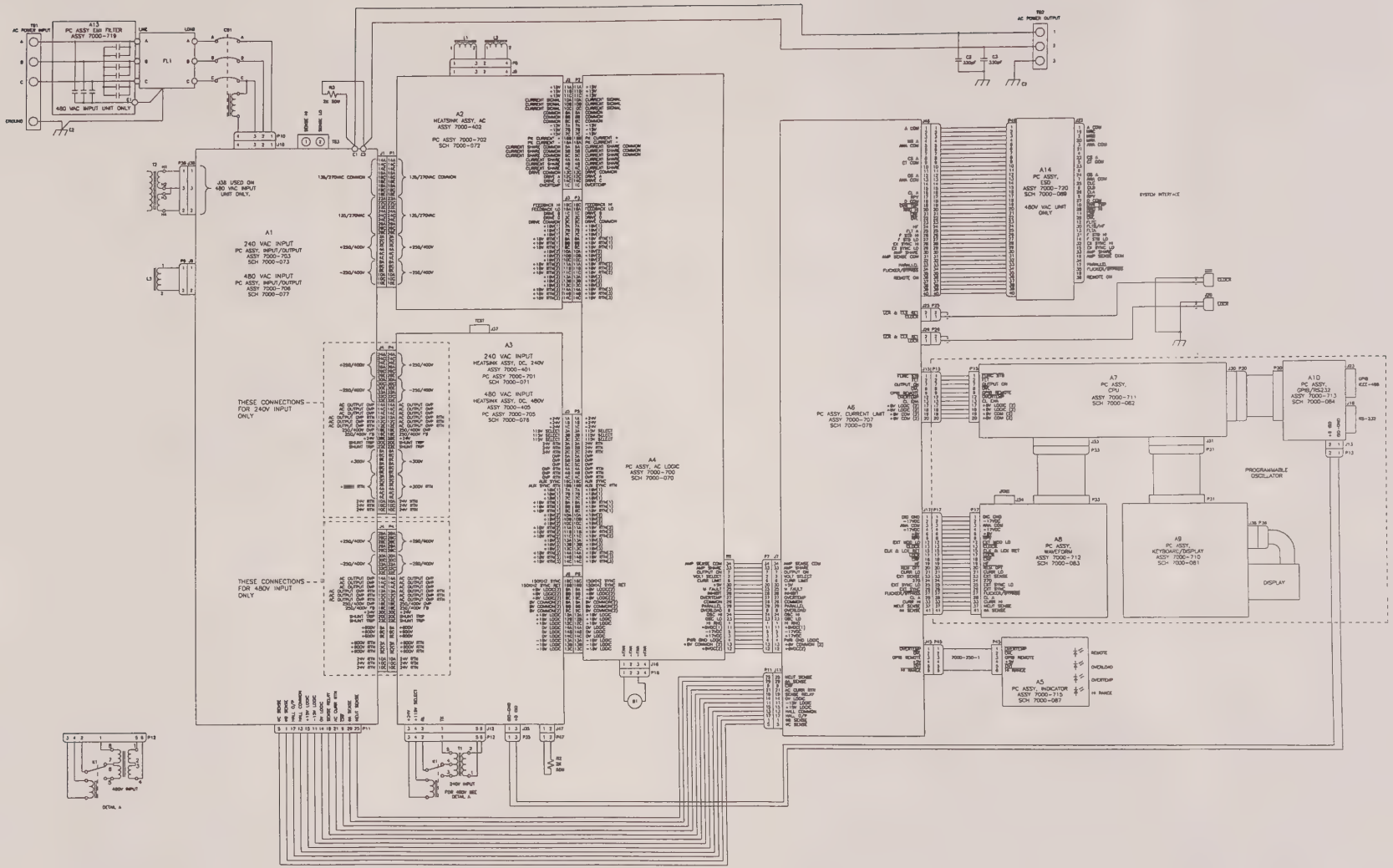


Figure 5-2
Oscillator Power Module Block Diagram

5.4 Current limit board

The current limit board, A6, receives the oscillator signal and passes it through an amplifier whose gain is controlled by a signal from the overcurrent circuit. The overcurrent circuit senses the rms value of the current. If the load current exceeds the programmed value the output of this sensing circuit reduces the output of the oscillator amplifier. The output of the unit then becomes a sinusoidal constant current output, with the output voltage dropping as the load increases.

When two or three units are connected as a single phase system the MRA output from the master oscillator amplifier drives all the power amplifiers, over the system interface cable. An overcurrent condition on any amplifier will act to reduce the output voltage and put the entire system into the sinusoidal constant current mode.

5.5 Auxiliary power supply

The aux. PS is mounted on the DC-DC power board. The auxiliary power supply generates nine low voltage outputs. These outputs from the aux. PS provide logic power to all the modules.

a) +/- 18V to the AC logic board and the oscillator.
b) +8V to the oscillator.
c) + 15V to the DC-DC converter.
d) Three + 18V supplies to the AC power amplifier gate drives.
e) +24V for the fan and relay power.
f) +8V for the digital front panel meter.

All the supplies a), b) and e) have a common ground. The supplies in c) and d) are all isolated from each other and from a), b) and e). LED's on the AC logic board and the AC power board are lit when each output is in regulation. If an overload condition causes the output to drop more than 10% or the output has failed the corresponding LED will extinguish. This feature is helpful in troubleshooting the unit. See Service section 7.

5.6 DC-DC power converter

The DC-DC power converter, A3, is powered from the rectified AC input. The converter is a PWM (pulse width modulated) full bridge type that uses IGBT's as the power switches and runs at 37.5 kHz. The control logic supply for the DC-DC converter is derived from the aux. PS so the DC-DC converter does not start switching until after the aux. PS has started up and comes into regulation. This feature ensures a smooth start up.

The output of the DC converter is automatically selected for 250V dc or 400V dc output depending on whether the low range output (135 Vac) or high range output (270 Vac) is selected. The 250/400V dc range selection is made by a relay that selects one of two taps on the DC output transformer. The converter is fully protected with input current limit and input and output overvoltage protection. When the output of the DC converter is up and in regulation the LED on the input output board will be lit. The LED can only be seen by looking directly down between the large storage capacitor and the input/output board. (See Figure 5-3)

5.7 AC control logic

The main function of the control board, A4, is to generate the gate drive signals for the AC power stage. This board also includes the circuit for the current limit and when two or three units are operated in parallel, the load sharing circuit. (See Figure 5-6)

The signal from the oscillator is fed through a low pass filter circuit and sent to the reference input of the error amplifier. The voltage output of the unit is differentially sensed and fed back to the error amplifier thereby completing the control loop. The output of the error amplifier drives a 37.5 kHz pulse width modulator. The modulator output is sent to four gate drivers which drive the IGBT's on the AC power board after going through optocouplers that provide the necessary isolation.

Figure 5-3: 5001i Internal Layout

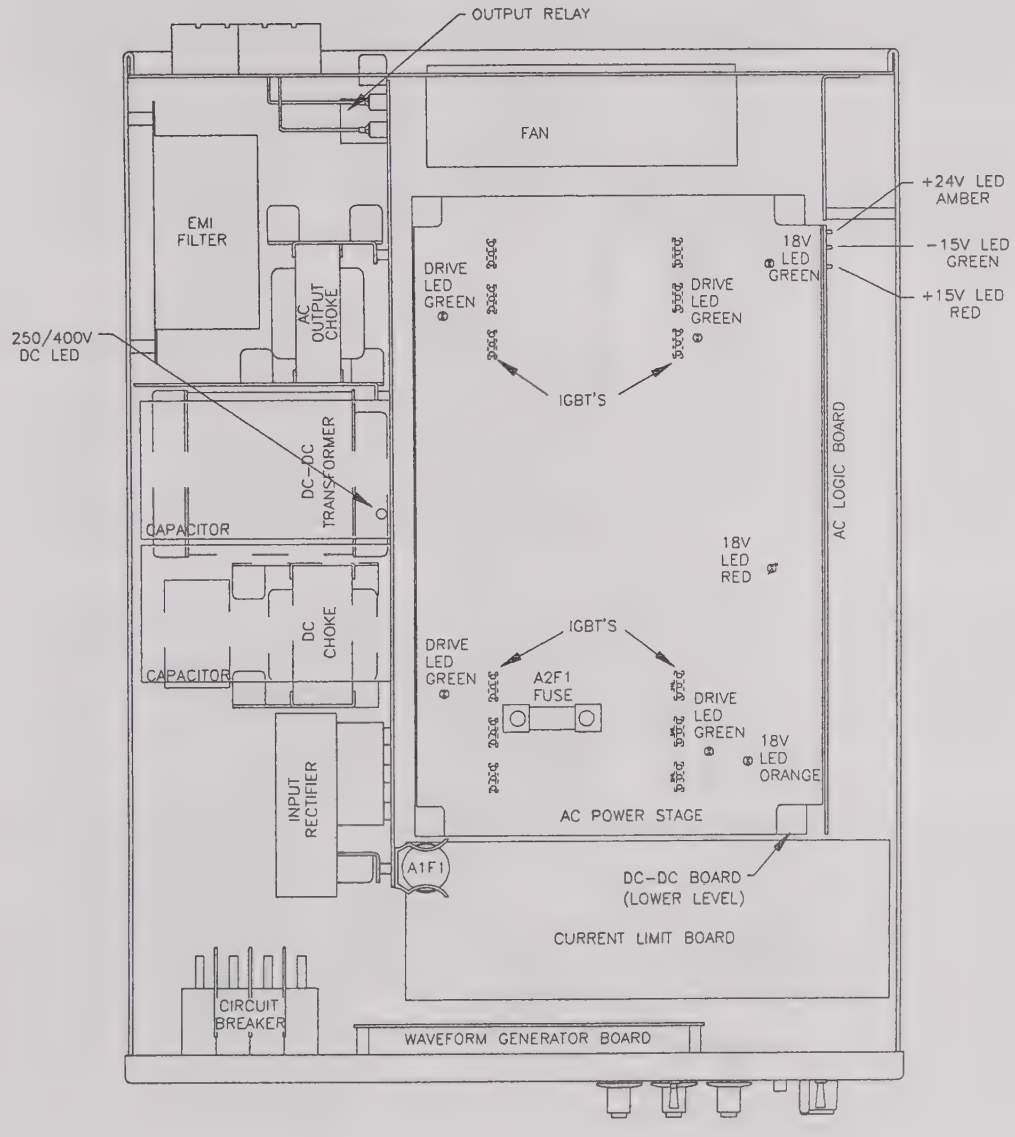
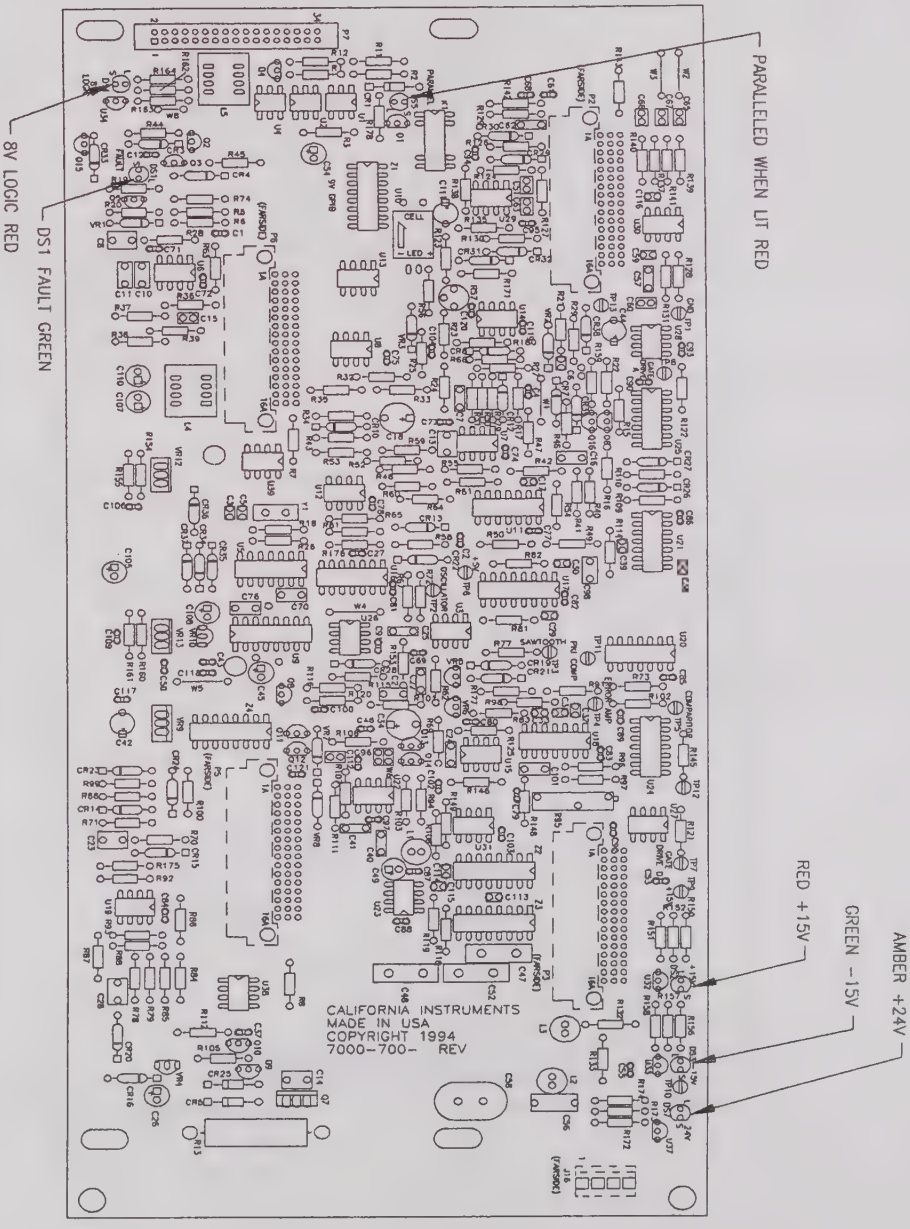


Figure 5-4: Logic Board LED's



There are six LED indicators on the logic board. Their positions are shown in Figure 5-4. The functions in Table 3.

Table 3 : Logic Board LED's

LED#	FUNCTION	COMMENTS
DS2	+15V	+15V logic supply
DS3	-15V	-15V logic supply
DS4	+8V	+8V oscillator supply
DS7	+24V	+24V supply for relays and logic.
DS5	PARALLEL	LED should be lit when units are paralleled and K1 is closed.
DS1	FAULT	LED is lit - unit normal. No light indicates pwr. stage failed

5.8 AC power board

The AC power assembly takes a 250V/400V DC input and generates a 135V/270V AC direct coupled output. The AC power amplifier is a full bridge inverter with three paralleled IGBT's in each leg for a total of twelve IGBT's. The switching frequency of the bridge is 37.5 kHz and this frequency is smoothed out by two inductors that are mounted behind the input/output board and several smoothing capacitors on the AC power board to provide a precision low frequency (16-500 Hz) output. (See Figure 5-3 and Figure 5-5)

Three isolated 18V supplies provide power for the gate drives. The 18V is regulated down to 15V by three TO220 regulators that are mounted on three discrete sheet metal heat sinks. If the 15V is in regulation an LED will be lit in front of each heat sink. There is a red, a green and an orange LED, one for each supply. The other four green LED's will be lit when there is gate drive present at the IGBT's. If the green LED's are not lit there will be no gate drive and hence no output.

5.9 Input/output board

The input/output board holds a lot of the large components and provides interconnection between the AC input, the DC-DC board, the AC power board and the output without the use of heavy cables. The output relay and the output current metering circuit are also mounted on this board. The output AC inductors, the DC-DC transformer and the DC output choke are mounted on brackets behind the input/output board. These brackets also provide support for the input/output board.

Figure 5-5: AC Power Stage Layout

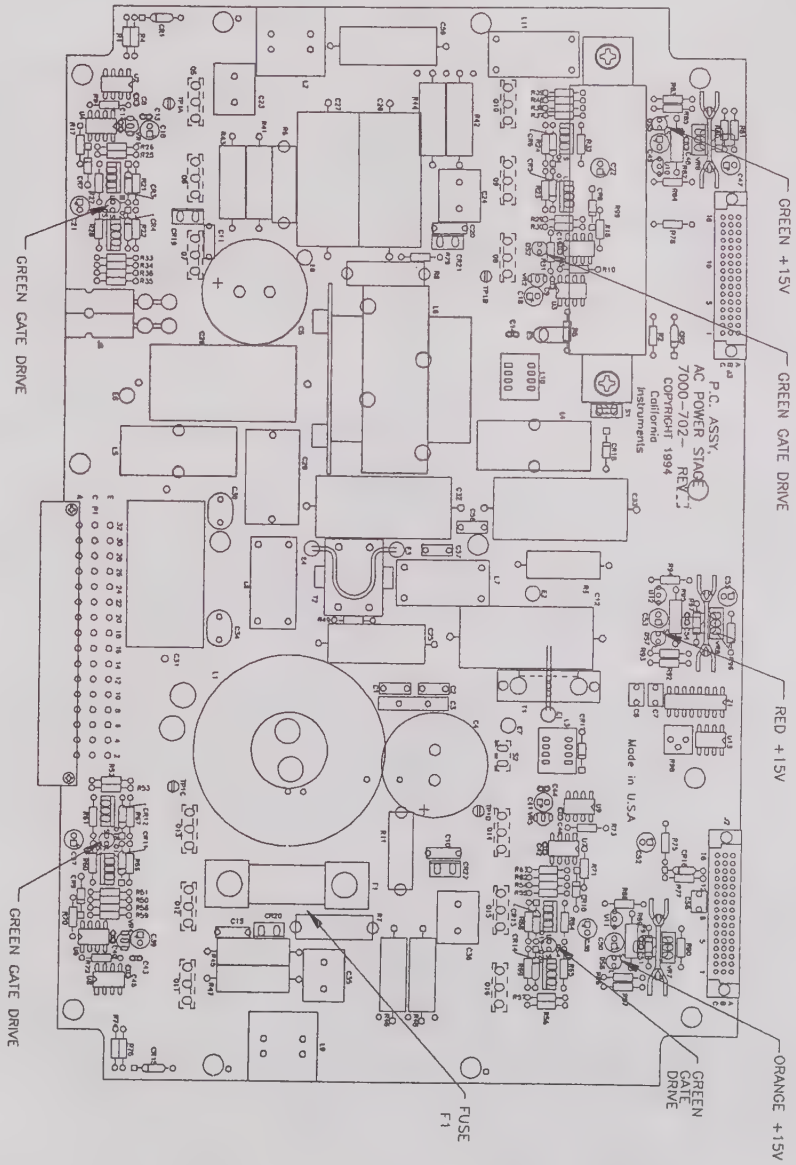
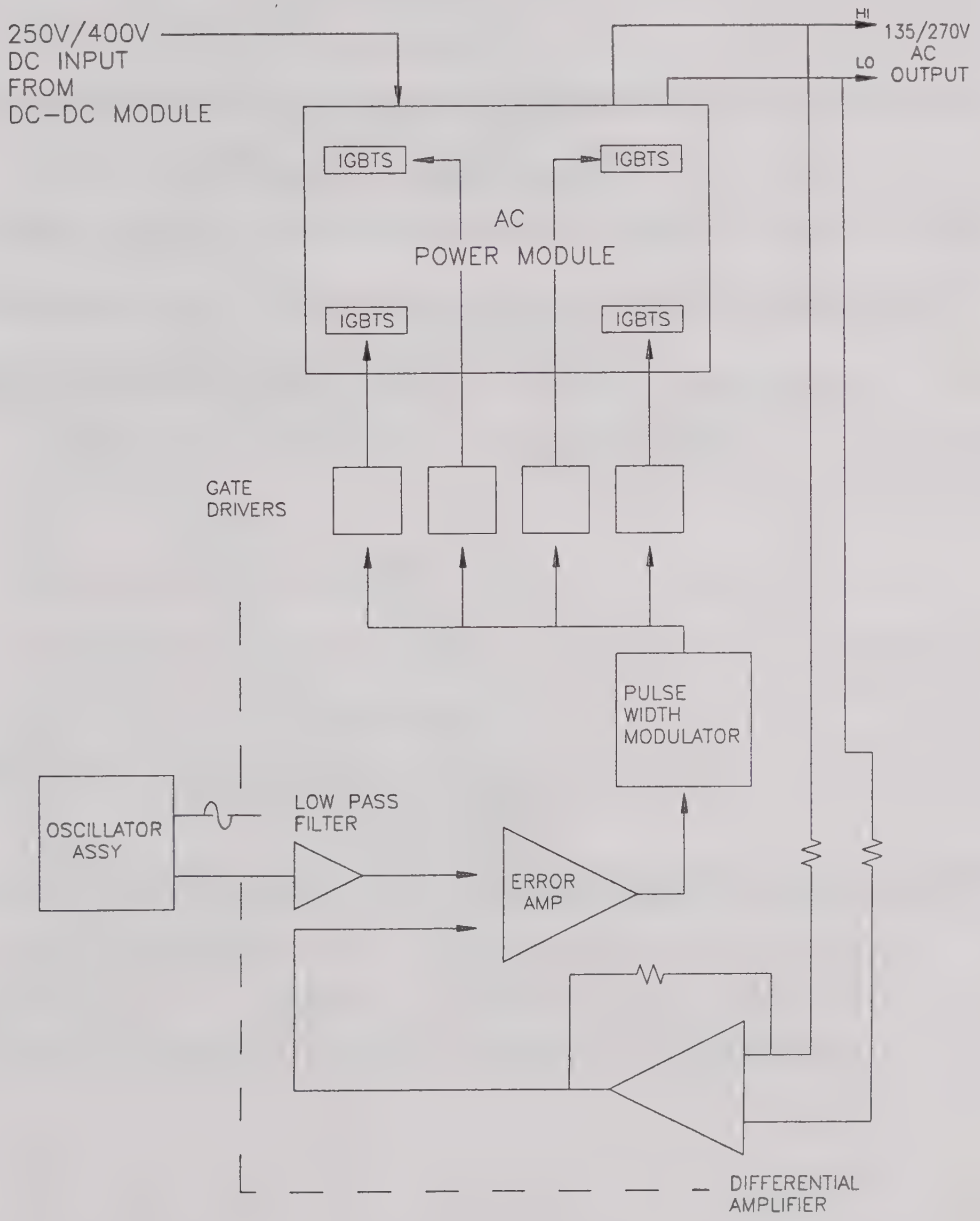
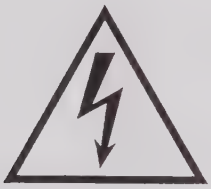


Figure 5-6: AC Control Logic Block Diagram





CAUTION

VOLTAGES UP TO 480 VAC AND 650 VDC ARE PRESENT IN CERTAIN SECTIONS OF THIS POWER SOURCE. THIS EQUIPMENT GENERATES POTENTIALLY LETHAL VOLTAGES.

DEATH

ON CONTACT MAY RESULT IF PERSONNEL FAIL TO OBSERVE SAFETY PRECAUTIONS. DO NOT TOUCH ELECTRONIC CIRCUITS WHEN POWER IS APPLIED.

6. Calibration

The Routine Calibration should be performed every 12 months. Non-routine Calibration is only required if a related assembly is replaced or if the periodic calibration is unsuccessful.

6.1 Calibration Equipment

Digital Multimeter:	Fluke 8506A or HP 34401A
10 milliohm Current Shunt:	Isotek Model RUG-Z-R010-0.1 or equivalent
1 milliohm Current Shunt: (10001i-1 & 15001i-1):	Isotek Model RUG-Z-R001-0.1
Load Bank:	Various high power load resistors will be needed.

6.2 The Output Calibration Screen

To show the OUTPUT CALIBRATION screen for the first time press the MENU key. Press the ↑ or ↓ key several times to highlight MORE. Press the ENTER key to show the MENU 2 screen. Select OUTPUT CAL and press ENTER. Type 5000 and press the ENTER key to show the OUTPUT CALIBRATION screen.

6.3 The Measurement Calibration Screen

To show the MEASUREMENT CALIBRATION screen follow the steps in paragraph 6.2. Select the MEASUREMENT CAL function instead of OUTPUT CAL from the MENU 2 screen. If another CALIBRATION screen has been accessed since power-up no password is needed. If a password is needed use the value 5000.

6.4 Routine Output Calibration

Setup:
Connect the test equipment to the power source as shown in Figure 6-1. If any output parameter can't be calibrated refer to the Power Source Gain Adjustment in the Non-routine Output Calibration section of the manual.

Figure 6-1: Test Equipment Hookup for Routine Output Calibration

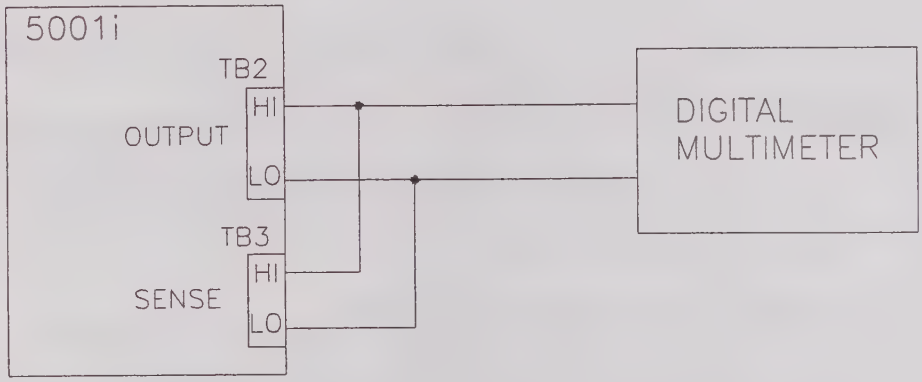


FIGURE 6-1

The Output Calibration Table is a summary of the output calibration procedure. The following text is a detailed explanation of the procedure.

135 VAC Range DC Zero:
Press the PROGRAM key and select the 135 Range with the shuttle. Program the output to 0.0 volts. Go the Output Calibration and select the VOLT ZERO parameter. Close the Output Relay by pressing the OUTPUT ON/OFF key. Monitor the DC output voltage with the external DVM. With shuttle control adjust the output voltage for 0.0 ± 0.005 VDC.

135 VAC Range Full-scale:
Press the PROGRAM key and program 120.0 volts and 60 Hz. Go to the OUTPUT CALIBRATION screen by choosing the PREVIOUS screen selection. Select the VOLT FS parameter and adjust the output to 120.0 ±0.05 volts.

135 VAC Range HI Freq:
Press the PROGRAM key and program the output to 120.0 volts and 300 Hz. Go the CALIBRATION screen and select the V HI FREQ parameter. Adjust the output with the shuttle for an output of 120.0 ±0.05 volts. Repeat the 60 Hz and 300 Hz adjustments until the output is within ±0.05 volts of the programmed value.

270 VAC Range DC Zero:
Program the output to the 270 VAC Range by pressing and selecting the 270 Range with the shuttle. Go the CALIBRATION screen, select the VOLT ZERO parameter and adjust the output to 0.0 ±0.005 VDC.

270 VAC Range Volt Full-scale:
Program the output to 240.0 volts and 60 Hz. Go to the CALIBRATION screen and adjust VOLT FS parameter for an output of 240.0 ±0.05 volts.

270 VAC Range Volt HI Freq:
Program the output to 240.0 volts and 300 Hz. Go to the CALIBRATION screen and select the V HI FREQ parameter. Adjust the output with the shuttle for an output of 240.0 ±0.05 volts. Repeat the 60 and 300 Hz adjustments until the output is within ±0.05 volts of the programmed value.

135 VDC Range Volt Zero:
Press the PROGRAM key. Select the MORE option to go to the PROGRAM 2 screen. Highlight the VOLTAGE MODE parameter and select the DC Mode by moving the shuttle. Press the PROGRAM key and program the 270 Range and 0.0 volts. Go to the Measurement Calibration by pressing the MENU key followed by pressing the ENTER key to display the MENU 2 screen. Select the MEASUREMENT screen and adjust the VOLT ZERO for 0.0 ±0.005 volts DC.

135 VDC Range + Full-scale:
Program +120.0 volts. Go to the OUTPUT CALIBRATION screen and adjust the VOLT FS parameter for an output voltage of +120.0 ±0.05 volts DC.

135 VDC Range - Full-scale:
Program -120.0 volts. Go to the OUTPUT CALIBRATION screen and adjust the VOLT FS parameter for an output voltage of -120.0 ±0.05 volts DC.

270 VDC Range + Full-scale:
Program + 240.0 volts. Go to the OUTPUT CALIBRATION screen and adjust the VOLT FS parameter for an output voltage of +240.0 ±0.05 volts DC.

270 VDC Range - Full-scale:
Program - 240.0 volts. Go the OUTPUT CALIBRATION screen and adjust the VOLT FS parameter for an output voltage of -240.0 ±0.05 volts DC.

Program the following values in the table and make the adjustments in the OUTPUT CALIBRATION screen.

Table 4 : Output Calibration Table

TITLE	PROGRAM VALUES	CALIBRATION VALUE	ADJUST TO
135 VAC range DC Zero	135 range, 0.0 V	VOLT ZERO	0 ± 5 mv DC
135 VAC range Volt FS	120.0 V, 60 Hz	VOLT FS	120 ±0.05 VAC
135 VAC range Volt Hi Freq	120.0 V, 300 Hz	V HI FREQ	120 ± 0.05 VAC
	Repeat adjustments at 60 and 300 Hz until output is within ± 0.05 volts		
270 VAC range DC Zero	270 range, 0.0 V	VOLT ZERO	0 ± 5 mv DC
270 VAC range Volt FS	240.0 V, 60 Hz	VOLT FS	240 ± 0.05 VAC
270 VAC range Volt Hi Freq	240.0 V, 300 Hz	VOLT HI FREQ	240 ± 0.05 VAC
	Repeat the adjustments at 60 and 300 Hz until the output is within ± 0.05 volts		
135 VDC range DC Zero	135 range, 0.0 V	VOLT ZERO	0 ± 5 mv DC
135 VDC range Volt +FS	+120.0 V	VOLT FS	+120 ± 0.05 VDC
135 VDC range Volt -FS	-120.0 V	VOLT FS	-120 ± 0.05 VDC
270 VDC range DC Zero	270 range 0.0 V	VOLT ZERO	0 ± 5 mv DC
270 VDC range Volt	+240.0 V	VOLT FS	+240± ± 0.05 VDC
270 VDC range Volt -FS	-240.0 V	VOLT FS	-240 ± 0.05 VDC

6.5 Routine Measurement Calibration

Connect the test equipment to the power source as shown in Figure 6-2. If the Current, Peak Current or Power Measurement can't be successfully performed, adjust the Current Measurement Pot. This adjustment is described in the Non-routine Calibration section of this manual.

Connect the load to the output. Use the 10 milliohm current shunt in series with the load to measure the AC and DC load current. When programming a DC load always program the output voltage to 0 volts before changing the output load. This will prevent the relays in the load bank from being damaged.

To calibrate all measurement functions the desired value must be entered for the corresponding calibration value. Make the indicated adjustments by typing in the desired display value. This should be the value indicated by the external DVM. The value for Power is in kW.

The Measurement Calibration Table is a summary of the measurement calibration procedure. The following text is a detailed explanation of the procedure.

Figure 6-2: Test Equipment Hook-up for Measurement Calibration

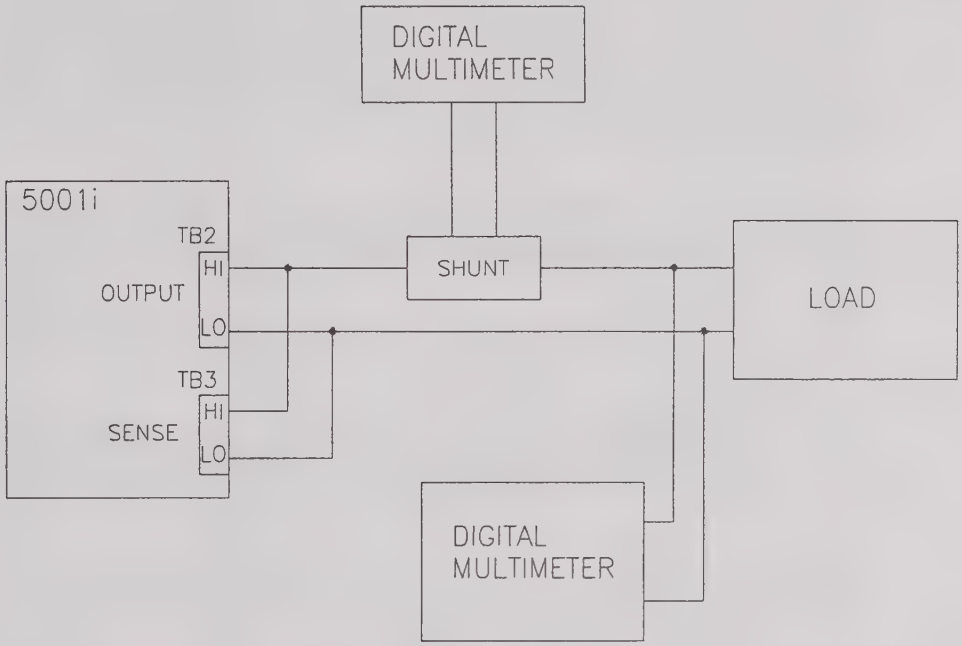


FIGURE 6-2

AC Volt Zero:
Program the output to the 270 volt range and 0.0 volts. Close the output relay. Go the MEASUREMENT CALIBRATION screen and select the VOLT ZERO parameter. Observe the AC output voltage on the AC Digital Multimeter (DVM). Enter the value of the output voltage for the VOLT ZERO parameter and press the ENTER key.

AC Volt Full-scale:
Program the output to 240 volts. Go to the MEASUREMENT CALIBRATION screen. Enter the actual AC output voltage for the VOLT FS parameter and press the ENTER key.

AC Current Zero:
Program the output to the 135 range, 135 volts and 60 Hz. Apply a 27 ohm load to the output. This load will draw approximately 5 amps from the output. Observe the actual output current by measuring the voltage from the current shunt 5 amps will be represented by 0.050 VRMS. Go to the MEASUREMENT CALIBRATION screen. Enter the value of the load current for the CURR ZERO parameter and press the ENTER key.

AC Power Zero:
Multiply the values for the actual voltage and load current. This value represents the output power. Enter this value in Kilowatts for the POWER ZERO parameter. (ex. 675 watts = 0.68 kW)

AC Peak Current Zero:
Multiply the load current by 1.414. Enter this value for the PK CUR ZERO parameter and press the ENTER key.

AC Current Full-scale:
Apply a 3.8 ohm, 5000 watt load resistor (6.3 ohm, 3000 watt for 3001i) to the output. Observe the actual output current and enter this value for the CURR FS parameter. Press the ENTER key.

AC Power Full-scale:
Multiply the values for the actual output voltage and load current. Enter this value in kilowatts for the POWER FS parameter and press the ENTER key.

AC Peak Current Full-scale:
Multiply the load current by 1.414. Enter this value for the PK CUR FS parameter and press the ENTER key.

DC Volt Zero:
Go to the PROGRAM 2 screen and program the DC mode. Go the PROGRAM screen and program the 270 range and 0.0 volts. Go to the MEASUREMENT CALIBRATION screen and enter the value of 0 for the VOLT ZERO parameter.

DC Volt +Full-scale:
Program the output to +240 volts. Go to the MEASUREMENT CALIBRATION screen. Enter the actual DC output voltage for the VOLT FS parameter and press the ENTER key.

DC Volt -Full-scale:
Program the output to -240 volts. Enter the actual DC output voltage for the VOLT FS parameter in the MEASUREMENT CALIBRATION screen. Remember to press the +/- key for the negative voltage.

DC Current Zero:
Program the output voltage to 0 volts. Apply a 67 ohm, 270 watt load to the output. This resistor will represent approximately a 2 amp load. Program the output to 135 volts. Enter the actual DC load current for the CURR ZERO parameter in the MEASUREMENT CALIBRATION screen and press the ENTER key.

DC Power Zero:

Multiply the value of the actual output voltage and the load current. Enter this value in kilowatts for the POWER ZERO parameter in the CALIBRATION screen.

DC Current Full-scale:
Program the output to 0 volts. Apply an 8 ohm , 2500 watt load resistor to the output. Program 135 volts. Enter the actual output current for the CURR FS parameter in the MEASUREMENT CALIBRATION screen.

DC Power Full-scale
Multiply the value of the actual output voltage and load current. Enter this value in kilowatts for the POWER FS parameter.

The value indicated by the External DVM is called Vac or V_{DC}. The current measured by the current shunt is called I_{ac} or I_{DC}.

Table 5: Measurement Calibration Table

TITLE	PROGRAM/LOAD PARAMETERS	PARAMETER	ADJUST TO
AC Volt Zero	270 Range, 0.0 volts	VOLT ZERO	V_{ac}
AC Volt Full-scale	240 VAC, 60 Hz	VOLT FS	V_{ac}
AC Current Zero	135 Range, 135 VAC, 27 ohm load	CURR ZERO	I_{ac}
AC Power Zero	135 Range, 135 VAC, 27 ohm load	POWER ZERO	$I_{ac} \times V_{ac}$
AC Peak Curr Zero	135 Range, 135 VAC, 27 ohm load	PK CUR ZERO	$I_{ac} \times \sqrt{2}$
AC Current Full-scale	135 Range, 135 VAC, 3.8 ohm load	CURR FS	I_{ac}
AC Power Full-scale	135 Range, 135 VAC, 3.8 ohm load	POWER FS	$I_{ac} \times V_{ac} \times 0.001$
AC Peak Curr. Full-scale	135 Range, 135 VAC, 3.8 ohm load	PK CUR FS	$I_{ac} \times \sqrt{2}$
DC Volt Zero	270 Range, 0.0 VDC	VOLT ZERO	0
DC Volt + Full - scale	+240 VDC	VOLT FS	V_{DC}
DC Volt - Full - scale	-240 VDC	VOLT FS	V_{DC}
DC Current Zero	135 Range, 135 VDC, 67 ohm load	CURR ZERO	I_{DC}
DC Power Zero	135 Range, 135 VDC, 67 ohm load	POWER ZERO	$I_{DC} \times V_{DC} \times 0.001$
DC Current Full-scale	135 Range, 135 VDC, 8 ohm load	CURR FS	I_{DC}
DC Power Full-scale	135 Range, 135 VDC, 8 ohm load	POWER FS	$I_{DC} \times V_{DC} \times 0.001$

6.6 Non-Routine Calibration

The non-routine calibration involves removing the top cover from the power source. Remove the line power from the power source before removing the top cover. Most of the adjustments are on the Current Limit Assembly. One adjustment is on I/O Board Assembly. Refer to Figure 6-3 for the location of the adjustments.

Power Zero Adjustment:

1. Program the DC voltage mode, 270 range and 0.0 VDC. Go to the MEASUREMENT CALIBRATION screen. By enabling the CALIBRATION screen, the measured value will show ± values for AC parameters. This is necessary to perform the Power Zero Adjustment.
2. Press the MEASURE key and record the measurement value for POWER. Program 270 VDC and adjust R23 on the I/O Board for the same Power measurement value as the one recorded in step 2.

Power Source Gain Adjustment:

Program 120 VAC on the 135 volt range and 300 Hz. Adjust R14 on the Current Limit Board for an output of 120 ±0.05 VAC.

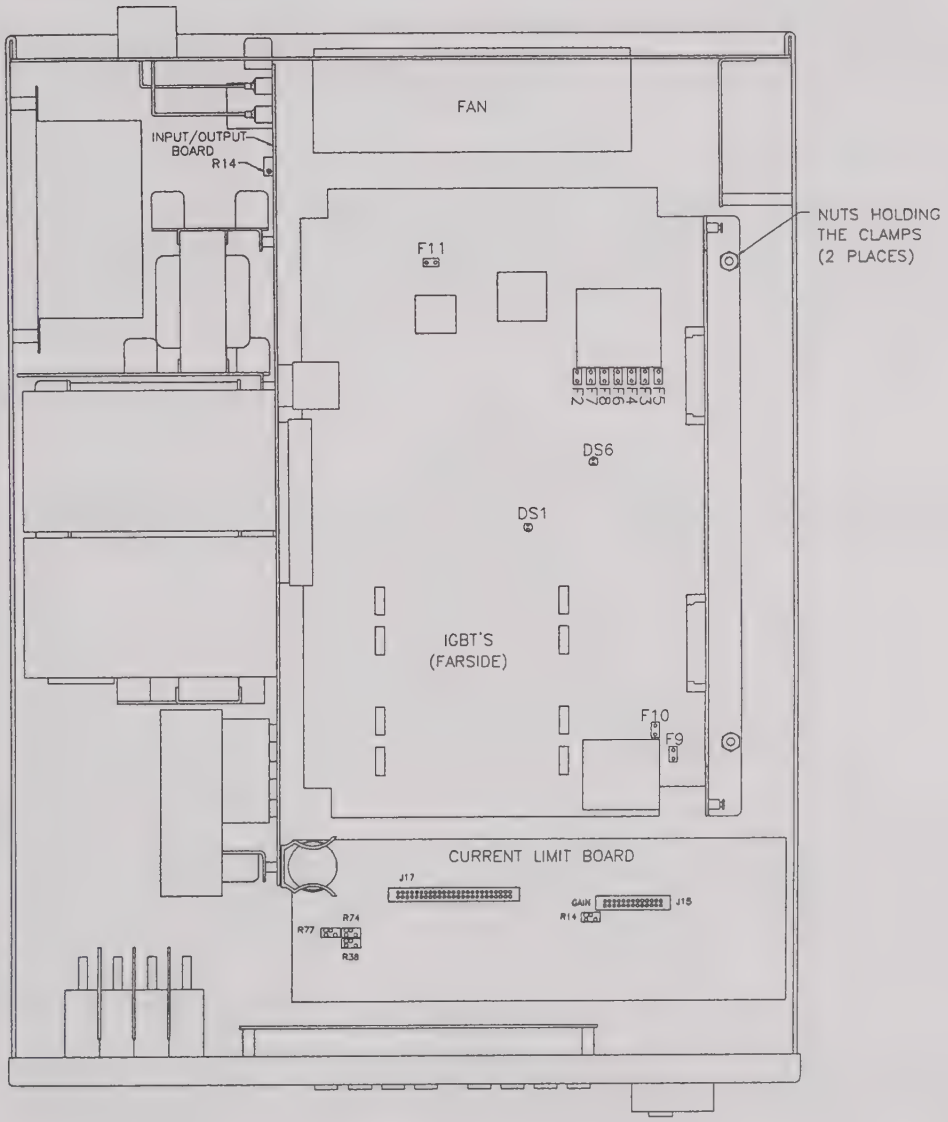
Current Amplifier Gain Adjustment:

Monitor the output load current with the shunt and AC DVM. Program 135 VAC on the 135 volt range and 60 Hz. Apply a load current between 33 and 37 amps (between 19.8 and 22.2 amps for 3001i). Go to the CURRENT MEASUREMENT screen. Adjust R74 on the Current Limit Board for a CURRENT measurement display equal to the load current.

Current Limit Adjustments:

Program the output to the 135 VAC range the current limit to 30 amps (18 amps for 3001i). Program the output to the constant current mode (CC). Apply a 3 ohm load to the output and adjust the output voltage for an output current of 33 amps (19.8 amps for 3001i). Adjust R38 on the Current Limit Board for an output current of 32 amps (19.2 amps for 3001i).
Program 0 VAC and remove the load. Monitor the voltage at TP9 on the Current Limit Board. Use TP1 as the ground. Adjust R77 on the Current Limit Board for the lowest DC voltage on TP9. Cycle the input power off and then on again.

Figure 6-3: Location of Internal Adjustments



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7. Service

7.1 Cleaning

The exterior of the power source may be cleaned with a cloth dampened with a mild detergent and wrung out. Disconnect mains power to the source before cleaning. Do not spray water or other cleaning agents directly on the power source.

7.2 General

This section describes the suggested maintenance and troubleshooting procedures. The troubleshooting procedure is divided into two sections. The first section deals with basic operation and connection of the equipment. The second section requires opening the unit and using the LED indicators and a simple multimeter to troubleshoot the unit down to the module level. Only a qualified electronic technician should attempt this level troubleshooting.

7.3 Basic operation

Table 6: Basic Symptoms

PARAGRAPH	PROBLEM
7.2.1	Excessive Output Voltage
7.3.2	Poor Output Voltage Regulation
7.3.3	Overload Light On
7.3.4	Distorted Output
7.3.5	Unit Shuts Down After 1-2 Seconds
7.3.6	No Output and no lights on front panel
7.3.7	No output but "power on" LED on front panel is lit.

7.3.1 Excessive output voltage

CAUSE	SOLUTION
External sense not connected	Connect the external sense to the AC power outlet TB2.

7.3.2 Poor output voltage regulation

CAUSE	SOLUTION
Unit is overloaded	Remove overload
Unit is programmed to wrong voltage range.	Select correct voltage range.
Input line has fallen below spec. limit.	Check supply voltage.

7.3.3 Overload light is on

CAUSE	SOLUTION
Unit is overloaded	Remove overload
Unit is switched to high voltage range.	Select correct voltage range.

7.3.4 Distorted output

CAUSE	SOLUTION
Power source is grossly overloaded.	Reduce load
The crest factor of the load exceeds 3:1 on the low range or 5:1 on the high range.	Reduce load current peaks by reducing load.

7.3.5 Unit shuts down after 1-2 seconds

CAUSE	SOLUTION
Output shorted	Remove output short
Output grossly overloaded.	Remove overload.
Operating load with too high inrush or start up currents.	Consult factory for application advice.

7.3.6 No output and no lights on front panel

CAUSE	SOLUTION
Input circuit breaker switched off.	Switch the breaker on.
No input power to TB3.	Ensure 3 phase power is getting to TB3.
Unit tripped on overvoltage or overcurrent.	Turn circuit breaker off - wait five seconds - turn circuit breaker back on.

7.3.7 No output but "power on" led on front panel is lit

CAUSE	SOLUTION
"OUTPUT ON" switch is turned off.	Turn OUTPUT ON switch to "ON".
REMOTE SHUTDOWN logic line at J22 pin 36 is shorted to D COM or A COM.	Remove connection from J22 pin 3.
Current limit programmed down or to zero.	Program current limit higher.
Voltage programmed down or to zero.	Turn amplitude control up.
Unit tripped on overvoltage or overcurrent.	Turn circuit breaker off - wait five seconds - turn circuit breaker back on.

7.4 Advanced troubleshooting.

WARNING: Do not connect 400-480V into the 208-240V unit, the result could be a severely damaged unit.

CAUTION: VOLTAGES UP TO 480 VAC AND 650 VDC ARE PRESENT IN CERTAIN SECTIONS OF THIS POWER SOURCE.

WARNING: THIS EQUIPMENT GENERATES POTENTIALLY LETHAL VOLTAGES. DEATH ON CONTACT MAY RESULT IF PERSONNEL FAIL TO OBSERVE SAFETY PRECAUTIONS. DO NOT TOUCH ELECTRONIC CIRCUITS WHEN POWER IS APPLIED

7.4.1 Switch off unit

Switch of the unit at the circuit breaker on the front panel as well as removing the input power from the unit.

WARNING: Wait 10 minutes for all internal capacitors to discharge.

7.4.2 Removing top cover

Remove the screws securing the top cover and remove the top cover.

7.4.3 Initial inspection

Make a visual inspection of the unit and ensure all the connectors are properly mated and there are no loose or broken wires.

7.4.4 Fuse check

See Figure 5-3 and Figure 5-5. Check the fuse F1 on the AC power board at the top of the unit using the ohmmeter. If the fuse is open do not replace but check all the IGBT's. To check the IGBT's connect the positive lead of the ohmmeter to the collector (center leg) and measure the resistance to the gate and the emitter (outside legs) of each IGBT. If the resistance reading is lower than 1000 ohms it indicates a blown IGBT. The IGBT's are not field replaceable and the module should be returned to the factory for exchange or repair. See paragraph 7.4.6. for disassembly instructions. If a low resistance reading is not found, replace the fuse and proceed with the check procedure.
Check the fuse F1 on the end of the input/output board. If the fuse is blown do not replace but proceed to paragraph 7.4.6 for disassembly instructions and remove the AC power board. With the AC power board removed check the IGBT's Q2 through Q9 using the procedure detailed in the paragraph above. See Figure 6-1: Internal Top View of DC-DC Converter Board.
If one or more IGBT's show a low resistance reading do not replace the fuse but return the module to the factory for exchange or repair. If a low resistance is not found replace the fuse and carry on with the check procedure.

7.4.5 Power on troubleshooting using the LED's.

If no fuses were blown or if fuses were found blown but all the IGBT's checked out as good, replace blown fuses and reconnect power to the unit.

WARNING: Do not touch any parts inside the unit during this test as they will be live and dangerous. Always wear safety glasses.

Select 60 Hz on the frequency controls, turn the amplitude control fully counterclockwise and the current limit to approximately 25% clockwise. Do not apply any load at this time as running the unit at high loads with the cover off will cause overheating of some components.

Auxiliary PS: Turn the main breaker on and check the LED's on the AC logic board.(see Figure 5-4). The +15V (DS2-red), -15V (DS3-green), and the 24V (DS7-amber) LED's located at the top right of the board should all be lit. The 8V logic supply LED (DS4- red) should be lit. On the AC power board (see Figure 5-5) the three gate drive power supply lights, DS5-red, DS6-amber, and DS7-blue, should all be lit. If any of these LED's are not lit then the most likely cause is a blown fuse. These logic power fuses are all located on the DC-DC board. Switch the unit off at the front panel breaker ***and*** remove the input power. ***Wait 10 minutes before attempting to disassemble the unit to allow for the capacitors to discharge.*** Proceed to paragraph 7.4.6. for disassembly instructions. Remove the AC power board and locate the P.C. mount fuses F2 through F10 (see Table 7 for fuse functions). Replace any blown fuses. Always replace fuses with same type and rating. (See Table 5).

Table 7: Auxiliary Power Supply Fuse Ratings

FUSE #	FUNCTION	FUSE VALUE
F2	DC-DC Converter logic	1 amp
F3	18V - AC gate drive (2)	1 amp
F4	18V - AC gate drive (3)	1 amp
F5	18V - AC gate drive (1)	1 amp
F6	24V Fan and relay power.	3 amp
F7	+15V logic power	1 amp
F8	-15V logic power	1 amp
F9	8V Front panel meter power	1 amp
F10	+8V logic power	1 amp
F11	Auxiliary power supply input fuse.	3 amp

Fuse F9 supplies power to the front panel meter. If F9 blows then there is no readout. If no LED's are on at all then the auxiliary power supply may have failed. Check F11 and replace if necessary. If none of these fuses has blown proceed to the next step.

DC-DC Converter: The output of the DC-DC converter 250V/400V will light the LED that is located directly down between the large storage capacitor and the input/output board (see Figure 5-3). This LED should be lit. If this LED is not lit, but the other aux. PS LED's are lit, then check F2 on the DC-DC board. See Table 7 and the preceding paragraph.

If no failures have been found to this point, then the AC power board has high power input and gate drive power. The gate drives on the AC power board should all be present (see Figure 5-5). These are the green LED's DS1 through DS4. They should all be lit. If they are not lit then the gate drive has been inhibited. Recheck paragraph 7.3.7 a) and c).

Oscillator: If the LED's DS1 through DS4 on the AC Power Board are lit and there is still no output then there may be no output from the oscillator. To check the oscillator output turn off the unit at the main breaker. Set the DVM to AC volts and connect the meter to Test Point 2 (TP2) with the return on TP1. See Figure 5-4. TP2 is in the center of the AC logic board and TP1 is at the top left. Turn the breaker back on. There should be a reading on the meter which can be varied from 0 to 5 volts by the amplitude knob on the front panel. If no reading is present check the output at the Waveform Generator Board. Check the signal between TP6 and TP1 (return) on the Waveform Generator Board. ***Switch power to the unit off before relocating probes.***

If a signal is present at the Waveform Generator Board but not at the AC Logic Board then the fault is in the wiring or the current limit board. Check the continuity of cables from the oscillator to the AC logic board. If there is no signal at TP6 then recheck the inhibit at paragraph 7.3.7 a) and c). or replace the oscillator assembly. The presence of the oscillator signal at the AC logic board would indicate a fault in the output relay or output wiring. See Figure 5-6.

AC output: Switch unit off - Check that P1 on the AC power board is making good contact with its mating half and J8 (the output to the AC smoothing inductors) is firmly engaged. Switch the unit back on and operate the power on/off switch on the front panel. Listen to hear if the relay operates. If the relay does not operate replace the input/output board. If it does, check the continuity of the output wiring.

If the problem with the unit has not been isolated, please contact the factory for assistance.

7.4.6 Disassembly procedure

Disconnect mains power to the source and ***wait 10 minutes before attempting to disassemble the unit to allow for the capacitors to discharge.*** Remove the top cover, unplug P7 from the current limit board, and unplug the fan from the AC logic board connector. Then carefully unplug the AC logic board from the AC and the DC power boards. The AC logic board can then be lifted from the unit.
Using a 5/16 inch socket driver remove the four bolts that hold the AC power module heatsink. There is one bolt at each corner. Carefully remove all the hardware from the unit. The AC power module can now be unplugged from the input/output board and removed from the unit.
The DC - DC module can be unplugged by first removing the two nuts holding the clamp that secures the heatsink to the chassis. See Figure 6-1. Care must be taken in unplugging the two connectors P4 and J12.

To reassemble, reverse the above procedure, taking care to ensure J12 on the DC-DC board and J8 on the AC board are properly mated. This may entail supporting the connector from behind with a screwdriver.

8. Top assembly replaceable parts

TOP ASSEMBLY No: 7000-412-1 3001i
7000-406-1 5001i, 240 VAC INPUT
7000-406-2 5001i, 480 VAC INPUT

Table 8: Replaceable Parts

SEQ#	CI PART #	DESCRIPTION	VENDOR	QTY.
A1	7000-703-1	240V - I/O PC ASSEMBLY, 5001i	CI	1
A1	7000-703-2	240V - I/O PC ASSEMBLY, 3001i	CI	1
A1	7000-706-1	480V - I/O PC ASSEMBLY, 5001i	CI	1
A2	7000-402-1	AC POWER MODULE	CI	1
A3	7000-401-1	240V - DC - DC POWER MODULE	CI	1
A3	7000-405-1	480V - DC - DC POWER MODULE	CI	1
A4	7000-700-1	LOGIC BOARD PC ASSEMBLY	CI	1
A6	7000-707-1	CURRENT LIMIT PC ASSEMBLY	CI	1
2	7000 404-1	PROGRAMMABLE OSC. FRONT PANEL ASSY.	CI	1
A10	7000-713-1	IEEE 488 BOARD	CI	1
B1	241183	FAN 6 INCH--JD24B2	Rotron	1
F1	270184	FUSE 30A 700V I/O & AC BOARDS	Bussman-KPB30	1
K1	245217	RELAY ON CHASSIS. KUHP-5DT1-24	Potter&Brumfield	1
F_{MISC}	270183	P.C. FUSES ON DC-DC BD, 3A F_6,F_{10},F_{11}	Bussman PCC-3	3
F_{MISC}	270174	P.C. FUSES ON DC-DC BD, 1A F_2-F_5, F_7-F_9	Bussman PCC-1	6
CB1	270186	INPUT CIRCUIT BREAKER 35A (240V), 5001i	AIRPAX 205-1111-28051-2	1
CB1	270196	INPUT CIRCUIT BREAKER 35A (250V), 3001i	AIRPAX IELK21-28851-1-V	1
CB1	270187	INPUT CIRCUIT BREAKER 15A (480V), 5001i	AIRPAX 205-1111-28051-2	1

SEQ#	CI PART #	DESCRIPTION
DC - DC POWER ASSY. 7000-701 AND 7000-706		
F2	270174	1 amp, 250 vac, quick acting
F3	270174	1 amp, 250 vac, quick acting
F4	270174	1 amp, 250 vac, quick acting
F5	270174	1 amp, 250 vac, quick acting
F6	270183	3 amp, 250 vac, quick acting
F7	270174	1 amp, 250 vac, quick acting
F8	270174	1 amp, 250 vac, quick acting
F9	270174	1 amp, 250 vac, quick acting
F10	270183	3 amp, 250 vac, quick acting
F11	270182	10 amp, 250 vac, time lag
F12	270182	10 amp, 250 vac, time lag
AC POWER ASSY. 7000-702		
F1	270184	30 amp, 700 vac, very quick acting
240 VOLT I/O ASSY. 7000-703		
F1	270184	30 amp, 700 vac, very quick acting
F2	270183	3 amp, 250 vac, quick acting
F3	270183	3 amp, 250 vac, quick acting
400 VOLT I/O ASSY. 7000-706		
F1	270185	15 amp, 700 vac, very quick acting
F2	270183	3 amp, 250 vac, quick acting
F3	270183	3 amp, 250 vac, quick acting

9. Options

9.1 Omni Option

9.1.1 General

The OMNI option is an impedance network adds resistive and inductive impedance to the output of 5001I power source. These addendum describe how to Bypass or Engage the OMNI form the 5001I source. For Specification and additional information refer to the OMNI user manual.

9.1.2 Front Panel Control

Select the APPLICATIONS screen from the MENU2 screen. The following screen will appear as shown in Figure 9-1

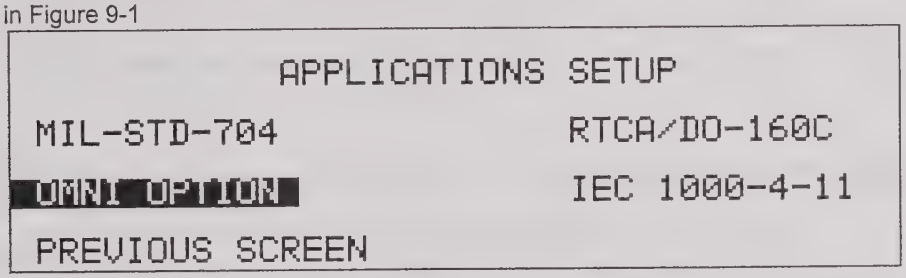


Figure 9-1 Applications Screen

Scroll to the OMNI OPTION entry using the up and down courser key. Press the ENTER key. The following MENU will appear as shown in Figure 9-2

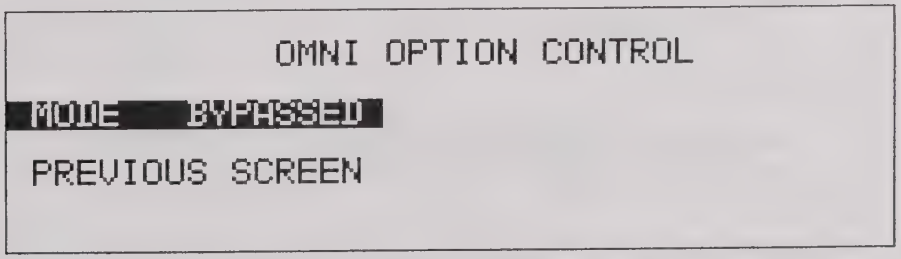


Figure 9-2 OMNI Control Screen

Scroll to the MODE entry using the up and down courser key. USE the Shuttle Knob to engage the OMNI. The display will indicate that the OMNI mode as shown in Figure 9-3

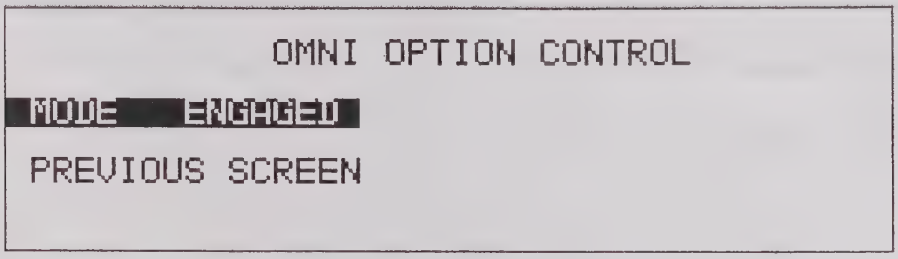


Figure 9-3 OMNI Control Screen

Note: The output of the AC source will drop for about 50 msec when the OMNI MODE changes state.

To Bypass the OMNI, turn the Shuttle Knob counter clock wise.

9.1.3 Remote Programming

The OMNI remote programming syntax is part of the Output subsystem.

Subsystem Syntax

```
OUTPut
    [:STATe] <bool>          Enable/disable the output voltage, current,power, etc.
    :TTLTrg
        [:STATe] <bool>      Enable/disable trigger out drive
        :SOURce<source>      Select a TTLTrg source(BOT|EOT|LIST)
    :OMNI
        [:STATe]<state>      Select the OMNI state (BYPassed|ENGaged)
```

OUTPut:OMNI[:STATe]

This command will engage or bypass the OMNI impedance network. The output voltage will drop when the state changes.

Command Syntax	OUTPut:OMNI[:STATe]<state>
Parameters	BYPassed | ENGaged
*RST Value	BYPassed
Examples	OUTP:OMNI ENG
Query Syntax	OUTPut:OMNI[:STATe]?
Returned Parameters	BYP|ENG
Related Commands	None

9.2 RTCA/DO-160C - Option

9.2.1 General

The RTCA/DO-160C option is capable of performing all sections of RTCA/DO-160C for the AC Source signal. This option is available in single phase AC source units only. In three phase AC Source, this option is available from the GUI (Graphical user interface) with the IEEE488 interface. Version 1.7 or later of the CIGUI is required to operate the DO160 option in three phase mode.

9.2.2 Initial Setup

Nominal parameters for the AC Power source are as follows:

Output Voltage	115V L-N
Output Frequency	400 Hz

9.2.3 Tests Performed

9.2.3.1 NORMAL STATE

1. Normal State Voltage and Frequency test
2. Waveform Distortion test
3. Voltage Modulation test
4. Frequency Modulation test
5. Momentary Power Interrupt (Undervoltage) test
6. Voltage Surge (Overvoltage) test

9.2.3.2 EMERGENCY TEST

1. Emergency Voltage and Frequency minimum
2. Emergency Voltage and Frequency maximum
3. Volatge unbalance

9.2.3.3 ABNORMAL TEST

1. Abnormal Voltage minimum
2. Abnormal Voltage maximum
2. Voltage Drop
3. Voltage Surge

9.2.4 Front Panel Entry

To perform a test from the keyboard, from the MENU 2 screen select the APPLICATIONS screen. The APPLICATIONS screen will appear as shown in Figure 9-4

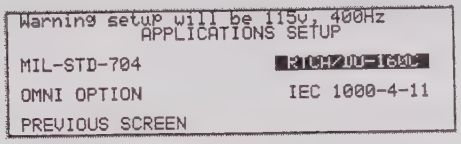


Figure 9-4: Application Menu

Scroll to the RTCA/DO-160C entry using the up and down cursor keys. Press the ENTER key to select the RTCA/DO 160C main menu. The screen will appear as shown in Figure 9-5. **The output voltage will be set to 115 volts and frequency to 400 Hz.***

***Note**: The user has to turn on the Output relay before starting a test

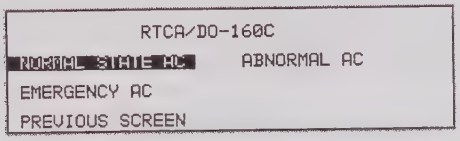


Figure 9-5: DO160 Main Menu

9.2.4.1 Normal state test

Scroll to the NORMAL STATE AC entry using the up and down cursor keys. Press the ENTER key to select the NORMAL STATE screens. The screen will appear as shown in Figure 9-6

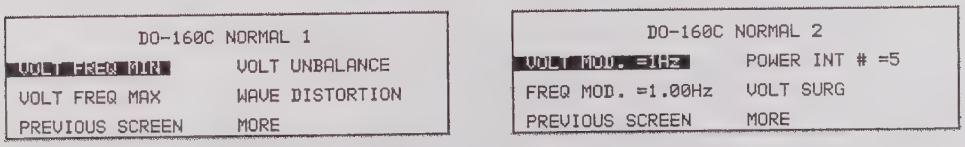


Figure 9-6: Nomal state

The DO160 NORMAL 1 and NORMAL 2 screens have the following tests

1. VOLT FREQ MIN
2. VOLT FREQ MAX
3. VOLT UNBALANCE
4. WAVEFORM DISTORTION
5. VOLT MODULATION
6. FREQ MODULATION
7. POWER INTERRUPT
8. VOLTAGE SURGE

The above tests can be selected by scrolling to the highlighted selection using the up and down key and the ENTER key to start the selected test. For some of these tests, numeric data entry may be required to define the test number or the modulation rate.

9.2.4.1.1 VOLT FREQ MIN

This test will change the output voltage from 115V to 104V and the output frequency from 400 Hz to 380 Hz. The test will last for 30 minutes. The ← Key (backspace) will terminate the test at any time.

9.2.4.1.2 VOLT FREQ MAX

This test will change the output voltage from 115V to 122V and the output frequency from 400 Hz to 420 Hz.. The test will last for 30 minutes. The ← Key (backspace) will terminate the test at any time.

9.2.4.1.3 VOLT UNBALANCE

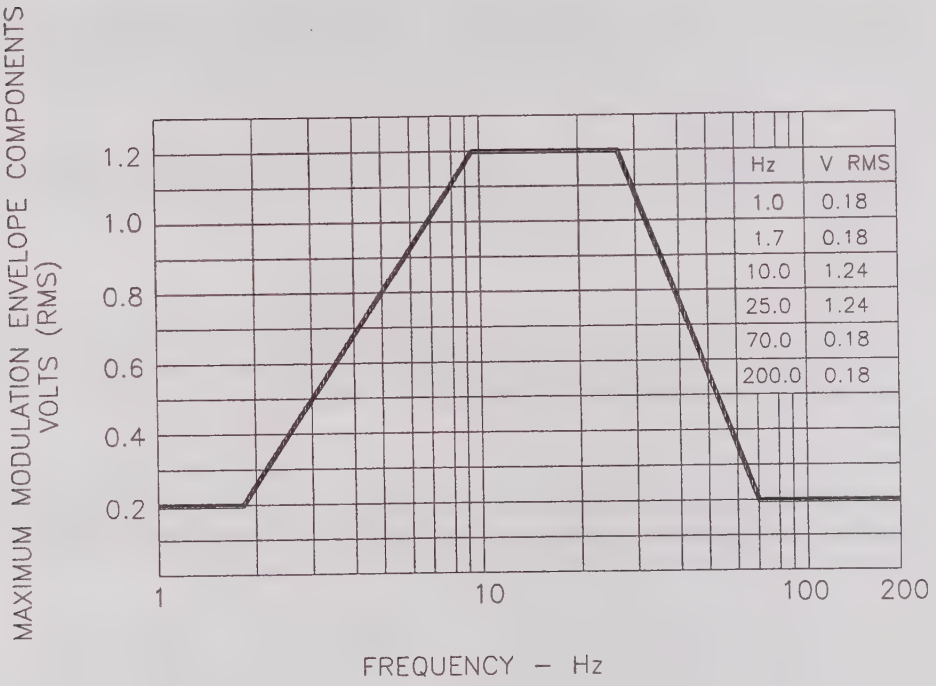
This test will set the output voltage to 112 volts for 5 minutes and to 118 volts for another 5 minutes before it returns to 115 volts. This test requires a three phase supply such as the 15003i, and not applicable for single phase. The ← Key will terminate the test at any time.

9.2.4.1.4 WAVEFORM DISTORTION

This test will generate a 5% THD voltage distortion on the output voltage waveform. The distortion is caused by using a clipped sinewave. The test will last for 30 minutes. The ← Key (backspace) will terminate the test at any time.

9.2.4.1.5 VOLTAGE MODULATION

This test requires a numeric value entry equal to the modulation rate in Hz. This entry value must be between 1 Hz and 200 Hz. The amplitude modulation is calculated based on the modulation rate as defined in Figure 9-7 . This test will last for 2 minutes.



FREQUENCY CHARACTERISTICS OF AC VOLTAGE MODULATION ENVELOPE

Figure 9-7: Voltage Modulation

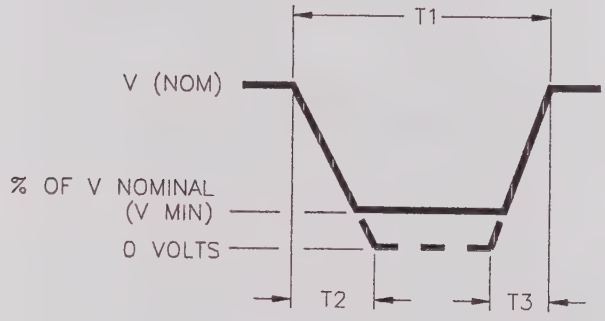
9.2.4.1.6 FREQUENCY MODULATION

This test requires a numeric value equal to the modulation rate in Hz. This value must be between 0.01 Hz and 100 Hz. The frequency modulation is calculated based on the modulation rate as defined in Figure 9-8. This test will last for 2 minutes.

Figure 9-8: Frequency Modulation

9.2.4.1.7 POWER INTERRUPT

This test requires numeric data entry from 1 through 15. This value represent the test number. Refer to Figure 9-9 for characteristic of each test.



NOTES: 1. Definitions
T1 – Power interrupt time.
T2 – Time it would take for the applied voltage to decay from V (nom) to zero volts>
T3 – Time it would take for the appliedvoltage to rise from zero to V (nom) volts.
V MIN – The minimum level (expressed as a percentage of V NOMINAL) to which the applied voltage is permitted to decay.

2. Tolerance to T1, T2 and V MIN = ±10%

TEST CONDITION NO.	1	2	3	1	5	6	7	8	9	10	11	12	13	14	15
T1 (MILLISECONDS)	2	10	25	50	75	100	200	1000	10	25	50	75	100	200	1000
T2 (MILLISECONDS)	<1	20*	20	20	20	20	20	20	50*	50*	50	50	50	50	50
T3 (MILLISECONDS)	<1	5	5	5	5	5	5	5	20	20	20	20	20	20	20
% OF V NOMINAL (V MIN)	0	50	15	10	5	0	0	0	20	50	0	15	5	0	0

* VOLTAGE WILL NOT REACH ZERO IN THIS TEST CONDITION.

Figure 9-9: Power Interrupt

9.2.4.1.8 VOLTAGE SURGE

This test require 160 volt output voltage. If the power source is set at the low voltage range, the high voltage range will be selected before the test starts. At the end of the test, the power source will be switched back to the low range automatticaly

The output voltage will remain at 115 volts for 5 minutes before the output voltage surges to 160 volts for 30 msec. The output voltage will remain at 115 volts for 5 seconds before it drops to 60 volts for 30 msec. The output voltage will remain at 115 volts for another 5 seconds. The above sequence will be repeated 2 more times before completion of the test. The ← Key will terminate the test at any time.

9.2.4.2 EMERGENCY TEST

From the DO160 MENU scroll to the EMERGENCY AC entry using the up and down cursor keys. Press the ENTER key to select the EMERGENCY screens. The screen will appear as shown in Figure 9-10.

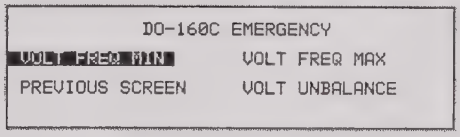


Figure 9-10: Emergency Screen

The EMERGENCY SCREEN has the following test:

1. VOLT FREQ MIN
2. VOLT FREQ MAX
3. VOLT UNBALANCE

The above tests can be selected by scrolling to the highlighted selection using the up and down key and the ENTER key to start the selected test.

9.2.4.2.1 VOLT FREQ MIN

This test will set the output voltage to 104 volts and the output frequency to 360 Hz. The test will last for 30 minutes before it returns to 115 volts and 400 Hz. The ← Key (backspace) will terminate the test at any time.

9.2.4.2.2 VOLT FREQ MAX

This test will set the output voltage to 122 volts and the output frequency to 440 Hz. The test will last for 30 minutes before it returns to 115 volts and 400 Hz. The ← Key (backspace) will terminate the test at any time.

9.2.4.2.3 VOLT UNBALANCE

This test will set the output voltage to 111 volts for 5 minutes and to 119 volts for another 5 minutes before it return to 115 volts. This test requires a three phase supply and not applicable for single phase.

9.2.4.3 ABNORMAL TEST

Form the DO160 MENU Scroll to the ABNORMAL AC entry using the up and down cursor keys. Press the ENTER key to select the ABNORMAL screens. The screen will appear as shown in Figure 9-11.

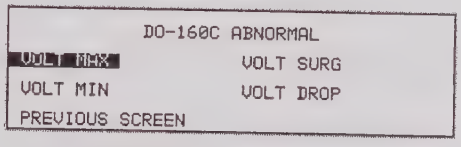


Figure 9-11: Abnormal Screen

The ABNORMAL SCREEN has the following test:

1. VOLT MAX
2. VOLT MIN
3. VOLT SURG
4. VOLT DROP

The above test can be selected by scrolling to the highlighted selection using the up and down key and the ENTER key to start the selected test.

9.2.4.3.1 VOLT MAX

This test will set the output voltage to 135 volts for 5 minutes before it returns to 115 volts. The ← Key (backspace) will terminate the test at any time.

9.2.4.3.2 VOLT MIN

This test will set the output voltage to 97 volts for 5 minutes before it returns to 115 volts. The ← Key (backspace) will terminate the test at any time.

9.2.4.3.3 VOLT SURGE

This test requires 180 volt output voltage. If the power source is set at the low voltage range, the high voltage range will be selected before the test starts. At the end of the test the AC source will be switched back to the low range.

The output voltage will surge to 180 volts for 100 msec. followed by drop to 148 volts for 1 sec before it returns to 115 volts. The ← Key (backspace) will terminate the test at any time.

9.2.5 Remote Control

The following are the remote commands set for DO-160C. ABORt command will terminate the test in progress at any time. Status checking via *OPC?; using *OPC 1 after DO160 command. This may be relevent for ATE applications in view of long test times.

DO160:NORMal:VOLT_FREQ :MINinum
DO160:NORMal:VOLT_FREQ :MAXimum
D0160:NORMal :WAVeform :DISTortion
DO160:NORMal:VOLTage :MODulation <numeric>
DO160:NORMal:FREQency :MODulation <numeric>
DO160:NORMal:VOLTage :INTerrupt <numeric>
DO160:NORMal:VOLTage :SURG

DO160:EMERgency :VOLT_FREQ :MINimum
DO160:EMERgency :VOLT_FREQ :MAXimum
DO160:EMERgency :VOLTage :UNBalance

DO160:ABNormal stage :VOLTage :MINimum
DO160:ABNormal state :VOLTage :MAXimum
DO160:ABNormal stage :VOLTage :UNDer
DO160:ABNormal state :VOLTage :OVER

9.3 IEC1000-4-11 - Option

9.3.1 Genteral

The IEC411 option is capable of performing IEC1000-4 section 11 Voltage dips, short interruptions and voltage variations immunity tests. This option is available in single phase AC Source. In three phase AC Source, this option is available from the GUI (Graphical user interface) with the IEEE488 interface. When used in a three phase system (15003I) through the GUI, a slight delay will occur between transitions on each individual phase. The user can select one, two or all three phases to be active during the IEC1000-4-11 tests in this configuration.

9.3.2 Initial Setup

The user must set the operating frequency and voltage as well as close the output relay prior to the start of test. It is possible to change the normal voltage (Ut) from the IEC1000-4-11 menu's before running each test.

9.3.3 Tests Performed

9.3.3.1 DIPS AND INTERRUPTIONS

1. Run All
   Run predefined sequence of tests.
2. Run Single
   Run user defined test.

9.3.3.2 VOLTAGE VARIATIONS

1. Run All
   Run predefined sequence of tests.
2. Run Single
   Run user defined test.

9.3.4 Front Panel entry

To perform a test from the keyboard, select the APPLICATIONS screen from the MENU 2 screen. The APPLICATIONS screen will appear as shown in Figure 9-12.

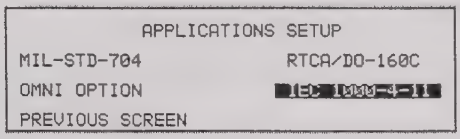


Figure 9-12 : Application menu

Scroll to the IEC 1000-4-11 entry using the up and down cursor keys. Press the ENTER key to select the IEC 1000-4-11 main menu. The screen will appear as shown in Figure 9-13.

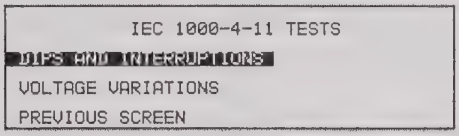


Figure 9-13 : IEC1000-4-11 Menu

9.3.4.1 DIPS AND INTERRUPTIONS TEST

Scroll to the DIPS AND INTERRUPTIONS entry using the up and down cursor keys. Press the ENTER key to select the DIPS AND INTERRUPTIONS menu. The screen will appear as Figure 9-14.

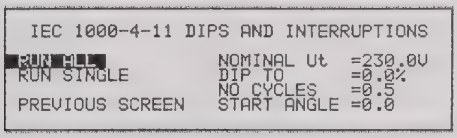


Figure 9-14: IEC Dips and Interrupts

9.3.4.1.1 RUN ALL

The RUN ALL selection will cause the following automated test sequence suggested by the standard to be run:

Step	Output in % of U_T	No of Cycles	Start angle (degrees)	Repeat # times	Delay between repeats (s)
1	0	0.5	0	3	10
2	0	0.5	180	3	10
3	0	1	0,45,90	3 at diff ø	10
4	0	5	45,90,135	3 at diff ø	10
5	0	10	90,135,180	3 at diff ø	10
6	0	25	180,225,270	3 at diff ø	10
7	0	50	270,315,0	3 at diff ø	10
8	40	0.5	0	3	10
9	40	0.5	180	3	10
10	40	1	0,45,90	3 at diff ø	10
11	40	5	45,90,135	3 at diff ø	10
12	40	10	90,135,180	3 at diff ø	10
13	40	25	180,225,270	3 at diff ø	10
14	40	50	270,315,0	3 at diff ø	10
15	70	0.5	0	3	10
16	70	0.5	180	3	10
17	70	1	0,45,90	3 at diff ø	10
18	70	5	45,90,135	3 at diff ø	10
19	70	10	90,135,180	3 at diff ø	10
20	70	25	180,225,270	3 at diff ø	10
21	70	50	270,315,0	3 at diff ø	10

The user can change the NOMINAL Ut voltage for this. The RUN ALL Command line will change to ABORT during the test. Selecting ABORT and pressing the ENTER key will terminate the test at any time and the output voltage will return to the nominal value.

9.3.4.1.2 RUN SINGLE

RUN SINGLE command will run a single test once. The Dip or Interrupt test is defined by the DIP TO, NO CYCLES, and START ANGLE parameters. These parameters must be set before starting the test. The following is a description of these parameters.

DIP TO: The dip voltage level as a percentage of the nominal voltage.
NO CYCLES: The dip duration in cycles.
START ANGLE: The start phase angle of the dip

Note: After each individual run, a 10 seconds delay is inserted.

9.3.4.2 VOLTAGE VARIATION TESTS

From the IEC1000-4-11 Main Menu screen shown in Figure 9-13. Scroll to VOLTAGE VARIATIONS entry using the up and down cursor keys. Press the ENTER key to select the VOLTAGE VARIATIONS menu. The screen will appear as shown in Figure 9-15.

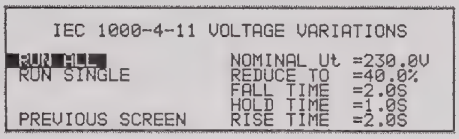


Figure 9-15 :Voltage Variation screen

9.3.4.2.1 RUN ALL

The RUN ALL selection will cause the following automated test sequence suggested by the standard to be run:

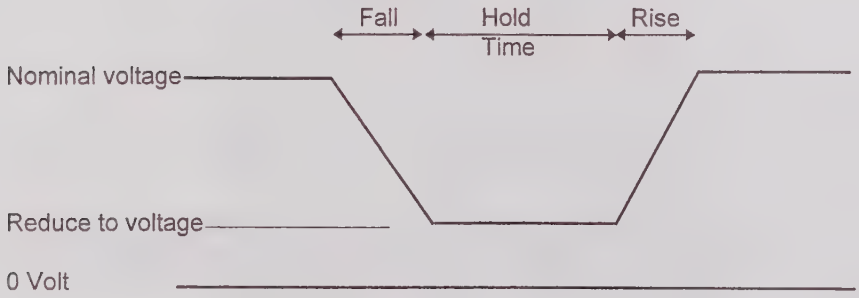
Step	Type	Start V in % of U_T	Dwell time	End V in % of U_T	Delay between steps (s)
1	VSweep	100	2	40	0
2	Hold	40	1	40	0
3	VSweep	40	2	100	10
4	VSweep	100	2	40	0
5	Hold	40	1	40	0
6	VSweep	40	2	100	10
7	VSweep	100	2	40	0
8	Hold	40	1	40	0
9	VSweep	40	2	100	10
10	VSweep	100	2	0	0
11	Hold	0	1	0	0
12	VSweep	0	2	100	10
13	VSweep	100	2	0	0
14	Hold	0	1	0	0
15	VSweep	0	2	100	10
16	VSweep	100	2	0	0
17	Hold	0	1	0	0
18	VSweep	0	2	100	10

The user can change the NOMINAL Ut voltage for this test. The RUN ALL Command line will change to ABORT during the test. Selecting ABORT and pressing the ENTER key will terminate the test at any time and the output voltage will return to the nominal value.

9.3.4.2.2 RUN SINGLE

RUN SINGLE command will run the test once. The Variation test is defined by the REDUCE TO, FALL TIME, HOLD TIME and RISE TIME parameters. These parameters must be set before starting the test. The following is a description of these parameters.

REDUCE TO:	The lowest voltage level as a percentage of the nominal voltage.
FALL TIME:	The time in seconds it will take the output to reach the REDUCE TO voltage.
HOLD TIME:	The time in seconds the output will hold at the REDUCE TO voltage.
RISE TIME:	The time in seconds the output will reach the NOMINAL voltage from the REDUCE to voltage



9.3.5 Remote control

The following are the remote commands set for IEC1000-4-11. The ABORt command will terminate the test in progress at any time. Test completion can be checked using the *OPC? query if the *OPC 1 command is issued immediately after an IEC1000-4-11 command. Upon completion of the test run *OPC? will return a 1. This may be relevant for ATE applications in view of long test times.

```
IEC411:
        [:NOMinal]
                :VOLTage
        :DIPS
                :RUN
                        [:ALL]
                        :SINGle
                :VOLTage
                        [:PERCent]
                :CYCLes
                :ANGLe
        :VARiants
                :RUN
                        [:ALL]
                        :SINGle
                :HOLD
                        :TIME
                        :VOLTage
                                [:PERCent]
                :FALL
                        [:TIME]
                :RISE
                        [:TIME]
```

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California Instruments

i - Series
SCPI Programming Manual
Section 2

SCPI **Programming Reference Manual**

i Series AC/DC Power Sources

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Rev G, December 1997

Safety Summary

The beginning of the AC/DC source User's Guide has a Safety Summary page. Be sure you are familiar with the information on this page before programming the AC source from a controller.

ENERGY HAZARD. AC sources can supply 425 V peak at their output. DEATH on contact may result if the output terminals or circuits connected to the output are touched when power is applied.

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1. Introduction

This manual contains programming information for the i Series AC/DC Power Sources. You will find the following information in the rest of this guide:

Chapter 1	Introduction
Chapter 2	Introduction to SCPI
Chapter 3	System Considerations
Chapter 4	SCPI Command Reference
Chapter 5	Programming Examples
Chapter 6	Status Registers
Appendix A	SCPI command tree.
Appendix B	SCPI conformance information.
Appendix C	Error messages

1.1 Documentation Summary

The following documents that are related to this Programming Guide have additional helpful information for using the AC source.

- Quick Start Guide. Information on how to quickly get started using the AC.dc source.
- User's Guide. Includes specifications and supplemental characteristics, how to use the front panel, how to connect to the instrument, and calibration procedures.

1.2 External References

SCPI References

The following documents will assist you with programming in SCPI:

- Beginner's Guide to SCPI.

Highly recommended for anyone who has not had previous experience programming with SCPI.

- **IEEE-488 References**

The most important IEEE-488 documents are your controller programming manuals -IEEE-488 Command Library for MS DOS, etc. Refer to these for all non-SCPI commands (for example: Local Device clear).

- IEEE-488 command library for MS DOS
- IEEE-488 controller programming

The following are two formal documents concerning the IEEE-488 interface:

- ANSI/IEEE Std. 488.1-1987 IEEE Standard Digital Interface for Programmable Instrumentation. Defines the technical details of the IEEE-488 interface. While much of

the information is beyond the need of most programmers, it can serve to clarify terms used in this guide and in related documents.

- ANSI/IEEE Std. 488.2-1987 IEEE Standard Codes, Formats, Protocols, and Common Commands. Recommended as a reference only if you intend to do fairly sophisticated programming. Helpful for finding precise definitions of certain types of SCPI message formats, data types, or common commands.

The above two documents are available from the IEEE (Institute of Electrical and Electronics Engineers), 345 East 47th Street, New York, NY 10017, USA.

1.3 Introduction to Programming

IEEE-488 Capabilities of the AC/DC Source

All AC/DC source functions are programmable over the IEEE-488. Care must be used when setting the IEEE-488 address since the next statement must reflect the new address. The IEEE 488.2 capabilities of the AC/DC source are listed in the appendix A of the User's Guide.

IEEE-488 Address

The AC/DC source operates from an IEEE-488 address that is set from the front panel or the IEEE-488 interface. To set the IEEE-488 address, select the Utility screen from the menu screen. The select the GPIB/RS232 setup screen.

2. Introduction to SCPI

SCPI (Standard Commands for Programmable Instruments) is a programming language for controlling instrument functions over the IEEE-488. SCPI is layered on top of the hardware-portion of IEEE 488.2. The same SCPI commands and parameters control the same functions in different classes of instruments. For example, you would use the same MEAS:VOLT? command to measure the AC/DC source output voltage or the output voltage of a SCPI-compatible multimeter.

2.1 Conventions Used in This Manual

Angle brackets<>	Items within angle brackets are parameter abbreviations. For example, <NR1> indicates a specific form of numerical data.
Vertical bar	Vertical bars separate alternative parameters. For example, FIX | STEP indicates that either "FIX" or "STEP" can be used as a parameter.
Square Brackets[]	Items within square brackets are optional. The representation [SOURce:]LIST means that SOURce: may be omitted.
Braces	Braces indicate parameters that may be repeated zero or more times. It is used especially for showing arrays. The notation <A> <,B> shows that parameter "A" must be entered, while parameter "B" may be omitted or may be entered one or more times.
Boldface font	Boldface font is used to emphasize syntax in command definitions. TRIGger:SOURCe<NRf> shows a command definition.
Computer font	Computer font is used to show program lines in text. TRIGger:SOURCe INT shows a program line.

2.2 The SCPI Commands and Messages

This paragraph explains the syntax difference between SCPI Commands and SCPI messages.

2.2.1 Types of SCPI Commands

SCPI has two types of commands, common and subsystem.

- Common commands are generally not related to specific operations but to controlling overall AC source functions such as reset, status and synchronization. All common commands consist of a three-letter mnemonic preceded by an asterisk: *RST *IDN? *SRE 256

- Subsystem commands perform specific AC/DC source functions. They are organized into an inverted tree structure with the "root" at the top. Some are single commands while others are grouped within specific subsystems.

Refer to appendix A for the AC source SCPI tree structure.

2.2.2 Types of SCPI Messages

There are two types of SCPI messages, program and response.

- A program message consists of one or more properly formatted SCPI commands sent from the controller to the AC/DC source. The message, which may be sent at any time, requests the AC/DC source to perform some action.

- A response message consists of data in a specific SCPI format sent from the AC source to the controller. The AC source sends the message only when commanded by a program message called a "query."

2.2.3 The SCPI Command Tree

As previously explained, the basic SCPI communication method involves sending one or more properly formatted commands from the SCPI command tree to the instrument as program messages. The following figure shows a portion of a subsystem command tree, from which you access the commands located along the various paths (you can see the complete tree in appendix A).

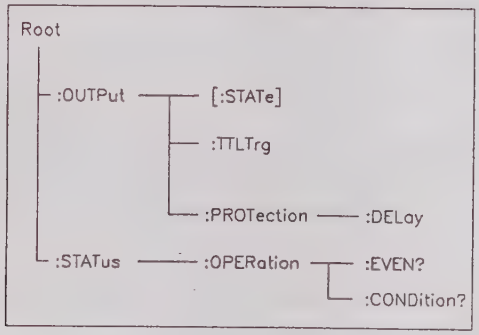


Figure 2-1 : Partial Command Tree

The Root Level

Note the location of the ROOT node at the top of the tree. Commands at the root level are at the top level of the command tree. The SCPI interface is at this location when:

- the AC/DC source is powered on
- a device clear (DCL) is sent to the AC source
- the SCPI interface encounters a message terminator
- the SCPI interface encounters a root specifier

Active Header Path

In order to properly traverse the command tree, you must understand the concept of the active header path. When the AC/DC source is turned on (or under any of the other conditions listed above), the active path is at the root. That means the SCPI interface is ready to accept any command at the root level, such as SOURCe or MEASurement

If you enter SOURCe the active header path moves one colon to the right. The interface is now ready to accept :VOLTage :FREQuency, or :CURRent as the next header. You must include the colon, because it is required between headers.

If you now enter :VOLTage, the active path again moves one colon to the right. The interface is now ready to accept either :RANGe or :LEVel as the next header.

If you now enter :RANGe you have reached the end of the command string. The active header path remains at :RANGe If you wished, you could have entered :RANGe 135 ;LEVel 115 and it would be accepted as a compound message consisting of:

1. SOURce:VOLTage:RANGe 135.

2. SOURce:VOLTage:LEVel 115.

The entire message would be:

SOURce:VOLTage:RANGe 135;LEVel 115

The message terminator after LEVel 115 returns the path to the root.

The Effect of Optional Headers

If a command includes optional headers, the interface assumes they are there. For example, if you enter [SOURCe]:VOLTage 115, the interface recognizes it as [SOURce]:VOLTage:LEVel 115. This returns the active path to the root (:VOLTage). But if you enter [SOURce]:VOLTage:LEVel 115 then the active path remains at :LEVel This allows you to send

[SOURce]:VOLTage:LEVel 115;RANGe 135

in one message. If you did not send LEVel you are allowed to send the following command:

[SOURce]:VOLTage 115;FREQuency 60

The optional header [SOURce] precedes the current, frequency, function, phase, pulse, list, and voltage subsystems. This effectively makes :CURRent,:FREQuency, :FUNCtion, :PHASe, :PULse, :LIST, and :VOLTage root-level commands.

Moving Among Subsystems

In order to combine commands from different subsystems, you need to be able to restore the active path to the root. You do this with the root specifier (:). For example, you could open the output relay and check the status of the Operation Condition register as follows:

OUTPut:STATe ON

STATus:OPERation:CONDition?

Because the root specifier resets the command parser to the root, you can use the root specifier and do the same thing in one message:

OUTPut on; :STATus:OPERation:CONDition?

The following message shows how to combine commands from different subsystems as well as within the same subsystem:

VOLTage:RANGe 135;LEVel 115;::CURRent 10;PROTection:STATe ON

Note the use of the optional header LEVel to maintain the correct path within the voltage and current subsystems and the use of the root specifier to move between subsytems. The "Enhanced Tree Walking Implementation" given in appendix A of the IEEE 488.2 standard is not implemented in the AC/DC source.

Including Common Commands

You can combine common commands with system commands in the same message. Treat the common command as a message unit by separating it with a semicolon (the message unit separator). Common commands do not affect the active header path; you may insert them anywhere in the message.

VOLTage:TRIGger 7.5;*TRG

OUTPut OFF;OUTPut ON;*RCL 2

2.3 Using Queries

Observe the following precautions with queries:

- Set up the proper number of variables for the returned data.
- Read back all the results of a query before sending another command to the AC source. Otherwise a Query Interrupted error will occur and the unreturned data will be lost.

2.4 Structure of a SCPI Message

SCPI messages consist of one or more message units ending in a message terminator. The terminator is not part of the syntax, but implicit in the way your programming language indicates the end of a line (such as a newline or end-of-line character).

2.4.1 The Message Unit

The simplest SCPI command is a single message unit consisting of a command header (or keyword) followed by a message terminator.

FREQuency?<newline>

VOLTage?<newline>

The message unit may include a parameter after the header. The parameter usually is numeric, but it can be a string:

VOLTage 20<newline>

VOLTage MAX<newline>

2.4.2 Combining Message Units

The following command message is briefly described here, with details in subsequent paragraphs.

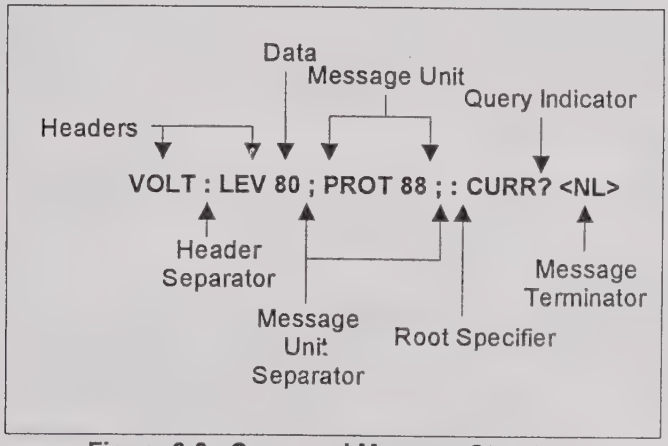


Figure 2-2 : Command Message Structure

The basic parts of the above message are:

Message Component	Example
Headers	VOLT LEV PROT CURR
Header Separator	The colon in VOLT:LEV
Data	8088
Data Separator	The space in VOLT 80 and PROT 88
Message Units	VOLT:LEV 80 PROT 88 CURR?
Message Unit Separator	The semicolons in VOLT:LEV 80; and PROT 88;
Root Specifier	The colon in PROT 88;:CURR?
Query Indicator	The question mark in CURR?
Message Terminator	The <NL> (newline) indicator. Terminators are not part of the SCPI syntax

2.4.3 Headers

Headers are instructions recognized by the AC/DC source. Headers (which are sometimes known as "keywords") may be either in the long form or the short form.

Long Form	The header is completely spelled out, such as VOLTAGE, STATUS, and OUTPUT.
Short Form	The header has only the first three or four letters, such as VOLT, STAT, and OUTP.

The SCPI interface is not sensitive to case. It will recognize any case mixture, such as TRIGGER, Trigger, TRIGger. Short form headers result in faster program execution.

Header Convention

In the command descriptions in chapter 4 of this manual, headers are emphasized with boldface type. The proper short form is shown in upper-case letters, such as DELay.

Header Separator

If a command has more than one header, you must separate them with a colon (VOLT:LEVel OUTPut:RELay:POLarity).

Optional Headers

The use of some headers is optional. Optional headers are shown in brackets, such as OUTPut[:STATe] ON. As previously explained under "The Effect of Optional Headers", if you combine two or more message units into a compound message, you may need to enter the optional header.

2.4.4 Query Indicator

Following a header with a question mark turns it into a query (VOLTage?, VOLTage:RANGe?). If a query contains a parameter, place the query indicator at the end of the last header (VOLTage:LEVel? MAX).

2.4.5 Message Unit Separator

When two or more message units are combined into a compound message, separate the units with a semicolon (STATus:OPERation?;QUEStionable?).

2.4.6 Root Specifier

When it precedes the first header of a message unit, the colon becomes the root specifier. It tells the command parser that this is the root or the top node of the command tree. Note the difference between root specifiers and header separators in the following examples:

CURRent:PROTection:DELay .1	All colons are header separators
:CURRent:PROTection:DELay .1	Only the first colon is a root specifier
CURRent:PROTection:DELay .1;:VOLTage 12.5	Only the third colon is a root specifier

You do not have to precede root-level commands with a colon; there is an implied colon in front of every root-level command.

2.4.7 Message Terminator

A terminator informs SCPI that it has reached the end of a message. Three permitted message terminators are:

- newline (<NL>), which is ASCII decimal 10 or hex 0A.
- end or identify (<END>)
- both of the above (<NL><END>).

In the examples of this manual, there is an assumed message terminator at the end of each message. If the terminator needs to be shown, it is indicated as <NL> regardless of the actual terminator character.

2.5 SCPI Data Formats

All data programmed to or returned from the AC source is in ASCII. The data type may be numerical or character string.

2.5.1 Numerical Data Formats

Symbol	Data Form
Talking Formats	
<NR1>	Digits with an implied decimal point assumed at the right of the least-significant digit. Examples: 273
<NR2>	Digits with an explicit decimal point. Example:.0273
<NR3>	Digits with an explicit decimal point and an exponent. Example: 2.73E+2
<Bool>	Boolean Data. Example: 0 | 1orON | OFF
Listening Formats	
<Nrf>	Extended format that includes <NR1>, <NR2> and <NR3>. Examples: 273273.2.73E2
<Nrf+>	Expanded decimal format that includes <Nrf> and MIN MAX. Examples: 273 273.2.73E2MAX,MIN and MAX are the minimum and maximum limit values that are implicit in the range specification for the parameter.
<Bool>	Boolean Data. Example: 0 | 1

2.5.2 Character Data

Character strings returned by query statements may take either of the following forms, depending on the length of the returned string:

<CRD> Character Response Data. Permits the return of character strings.

<AARD> Arbitrary ASCII Response Data. Permits the return of undelimited 7-bit ASCII. This data type has an implied message terminator.

<SRD> String Response Data. Returns string parameters enclosed in double quotes.

3. System Considerations

This chapter addresses some system issues concerning programming. These are AC/DC Source addressing and the use of the following IEEE-488 system interface controllers:

- HP 82335A GP-IB Controller
- PC controller with National Instruments GPIB-PCII Interface/Handler

3.1 Assigning the IEEE-488 Address in Programs

The AC source address can be set remotely and localy. It must be set from the front panel. Once the address is set, you can assign it inside programs. The following examples assume that the IEEE-488 select code is 7, and the AC source will be assigned to the variable ACS.

```
1070 ACS 706                    !HP82335A Interface
1070 ASSIGN @ACS TO 706         !HP BASIC Interface
```

For systems using the National Instruments DOS driver, the address is specified in the software configuration program (IBCONFIG.EXE) and assigned a symbolic name. The address then is referenced only by this name within the application program (see the National Instruments GP-IB documentation).

3.2 Types of DOS Drivers

The HP 82335A and National Instruments GP-IB are two popular DOS drivers. Each is briefly described here. See the software documentation supplied with the driver for more details.

3.2.1 HP 82335A Driver

For GW-BASIC programming, the IEEE-488 library is implemented as a series of subroutine calls. To access these subroutines, your application program must include the header file SETUP.BAS, which is part of the DOS driver software.

SETUP.BAS starts at program line 5 and can run up to line 999. Your application programs must begin at line 1000. SETUP.BAS has built-in error checking routines that provide a method to check for IEEE-488 errors during program execution. You can use the error-trapping code in these routines or write your own code using the same variables as used by SETUP.BAS.

3.2.2 National Instruments GP-IB Driver

Your program must include the National Instruments header file DECL.BAS. This contains the initialization code for the interface. Prior to running any applications programs, you must set up the interface with the configuration program (IBCONF.EXE).

Your application program will not include the AC source symbolic name and IEEE-488 address. These must be specified during configuration (when you run IBCONF.EXE). Note that the primary address range is from 0 to 30 but any secondary address must be specified in the address range of 96 to 126. The power supply expects a message termination on EOI or line feed, so set EOI w/last byte of Write. It is also recommended that you set Disable Auto Serial Polling.

All function calls return the status word IBSTA%, which contains a bit (ERR) that is set if the call results in an error. When ERR is set, an appropriate code is placed in variable IBERR%. Be sure to check IBSTA% after every function call. If it is not equal to zero, branch to an error handler that reads IBERR% to extract the specific error.

Error Handling

If there is no error-handling code in your program, undetected errors can cause unpredictable results. This includes "hanging up" the controller and forcing you to reset the system. Both of the above DOS drivers have routines for detecting program execution errors.

Important: Use error detection after every call to a subroutine.

3.3 RS232C Interface

The RS232C interface can be used as an alternative to the IEEE-488 if no IEEE-488 controller is available. A suitable cable to connect the i Series AC/DC Source to a 9 pin PC-AT style serial port is supplied with the source. If you are unable to locate this cable, you need to use a cable that conforms to the wiring diagram shown in figure TBD.

3.3.1 Serial Communication test program

The following sample program written in GW-BASIC can be used to check communication to the i Series source over the RS232C serial interface.

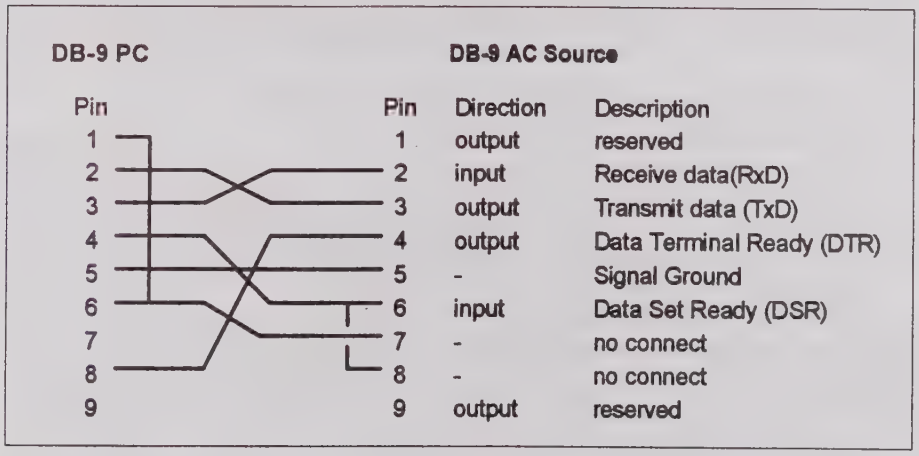
```
'California Instruments i Series RS232C Communication Demo Program
'(c) 1995 Copyright California Instruments, All Rights Reserved
'This program is for demonstration purposes only and is not to be
'used for any commercial application
'=================================================================
'OPEN COM2. Replace with COM1, COM3 or COM4 for Com port used
'The input and output buffers are set to 2K each although
'this is not required for most operations.
OPEN "COM2:9600,n,8,1,BIN,TB2048,RB2048" FOR RANDOM AS #1
CLS
PRINT "***** INTERACTIVE MODE *****"
'Enter and endless loop to accept user entered commands
DO
    INPUT "Enter AC Source Command ('quit' to exit)--> ", cmd$
    IF cmd$ <> "QUIT" AND cmd$ <> "quit" THEN
        PRINT #1, cmd$ + CHR$(10);
        IF INSTR(cmd$, "?") THEN
            PRINT #1, CHR$(4);
            LINE INPUT #1, response$
            PRINT response$
        END IF
        'Check for Errors after each command is issued
        PRINT #1, "*ESR?" + CHR$(10);
        PRINT #1, CHR$(4);
        LINE INPUT #1, esr$
```

```
        esr% = VAL(esr$) AND 60
        IF esr% AND 4 THEN
          PRINT "*** Query Error Reported by AC Source ***"
        END IF
        IF esr% AND 8 THEN
          PRINT "*** Instrument Dependent Error Reported by AC Source ***"
        END IF
        IF esr% AND 16 THEN
          PRINT "*** Command Execution Error Reported by AC Source ***"
        END IF
        IF esr% AND 32 THEN
          PRINT "*** Command Syntax Error Reported by AC Source ***"
        END IF
    END IF
LOOP UNTIL cmd$ = "QUIT" OR cmd$ = "quit"
'Close COM port on exit
CLOSE #1
END
```

3.3.2 Serial Cable Diagram

The following wiring diagram is required for the serial interface cable between the i Series

Figure 3-1 : RS232C Interface cable wiring diagram



power source and a PC communications port connector.

4. SCPI Command Reference

4.1 Introduction

Related Commands

Where appropriate, related commands or queries are included. These are listed because they are either directly related by function, or because reading about them will clarify or enhance your understanding of the original command or query.

This chapter is organized as follows:

- Subsystem commands, arranged by subsystem
- IEEE 488.2 common commands

4.2 Subsystem Commands

Subsystem commands are specific to AC/DC source functions. They can be a single command or a group of commands. The groups are comprised of commands that extend one or more levels below the root. The description of common commands follows the description of the subsystem commands.

The subsystem command groups are listed in alphabetical order and the commands within each subsystem are grouped alphabetically under the subsystem. Commands followed by a question mark (?) take only the query form. When commands take both the command and query form, this is noted in the syntax descriptions.

4.2.1 Calibration Subsystem

The commands in this subsystem allow you to do the following:

- Enable and disable the calibration mode
- Change the calibration password
- Calibrate the current and voltage output levels, and store new calibration constants in nonvolatile memory.

Subsystem Syntax

CALibrate	
:PASSword	A password is required to start calibration.
:MEASure	
:CURRent	
[:AC]	
[:FSCale]	Calibrate full scale AC current measurements
:ZERO	Cancel AC current measurements offset
:AMPLitude	
MAXampl	
[:FSCale]	Calibrate full scale peak current measurements
:ZERO	Cancel peak current measurements offset
:DC	
[:FSCale]	Calibrate full scale dc current measurements
:ZERO	Cancel dc current measurements offset
:POWer	
[:AC]	
[:FSCale]	Calibrate full scale AC power measurements
:ZERO	Cancel AC power measurements offset
:DC	
[:FSCale]	Calibrate full scale dc power measurements
:ZERO	Cancel DC power measurements offset
:VOLTage	
[:AC]	
[:FSCale]	Calibrate full scale AC voltage measurements
:ZERO	Cancel AC voltage measurements offset
:DC	
[:FSCale]	
[:POSitive]	Calibrate full scale dc positive voltage measurements
:ZERO	Cancel DC voltage measurements offset
[:SOURce]	
:PHASe	Calibrate output phase angle relative to external sync.
:VOLTage	
[:AC]	
:LRANge	
[:FSCale]	Calibrate full scale output voltage at low voltage range
:ZERO	Trim output voltage offset at low voltage range.
:HFRequency	Calibrate full scale output voltage at low voltage range and high frequency.
:HRANge	

[:FSCale]	Calibrate full scale output voltage at high voltage range
:ZERO	Trim output voltage offset at high voltage range.
:HFRequency	Calibrate full scale output voltage at high voltage range and high frequency.
:DC	
:LRANge	
[:FSCale]	
[:POSitive]	Calibrate full scale output dc positive voltage at low voltage range
:NEGative	Calibrate full scale output dc negative voltage at low voltage range
:ZERO	Trim output dc voltage offset at low voltage range.
:HRANge	
[:FSCale]	
[:POSitive]	Calibrate full scale output dc positive voltage at high voltage range
:NEGative	Calibrate full scale output dc negative voltage at high voltage range
:ZERO	Trim output dc voltage offset at high voltage range.

CALibrate:PASSword

This command allows the entry of the calibration password. A password is required to calibrate the instrument or to update the calibration coefficents.

Command Syntax	CALibrate:PASSword<SRD>
Parameters	<model number> (default)
Examples	CAL:PASS 'I3459' CAL:PASS "SP3546"
Related Commands	CAL:SNUMber

CALibrate:MEASure:CURRent[:AC][:FSCale] <NRf>

This command initiates the calibration of the AC current measurement at full scale.

Command Syntax	CALibrate:MEASure:CURRent
Parameters	<NRf> (actual load current measured with external device)
Examples	CAL:MEAS:CURR 11.5
Query Syntax	CALibrate:MEASure:CURRent?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:CURRent[:AC]:ZERO

CALibrate:MEASure:CURRent[:AC]:ZERO <NRf>

This command initiates the offset adjustment of the AC current measurement.

Command Syntax	CALibrate:MEASure:CURRent:ZERO
Parameters	<NRf> (0 or desired offset value)
Examples	CAL:MEAS:CURR:ZERO
Query Syntax	CALibrate:MEASure:CURRent:ZERO?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:CURRent[:AC][:FSCale]

CALibrate:MEASure:CURRent:AMPLitude:MAXampl[:FSCale] <NRf>

This command initiates the calibration of the AC peak current measurement at full scale.

Command Syntax	CALibrate:MEASure:CURRent:AMPLitude:MAXampl[:FSCale]
Parameters	<NRf> (actual peak current measured with external device)
Examples	CAL:MEAS:CURR:AMPL:MAX 15
Query Syntax	CALibrate:MEASure:CURRent:AMPL:MAX?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	none

CALibrate:MEASure:CURRent:DC[:FSCale] <NRf>

This command initiates the calibration of the dc current measurement at full scale.

Command Syntax	CALibrate:MEASure:CURRent:DC
Parameters	<NRf> (actual load current measured with external device)
Examples	CAL:MEAS:CURR:DC 11.5
Query Syntax	CALibrate:MEASure:CURRent:DC?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:CURRent:DC:ZERO

CALibrate:MEASure:CURRent:DC:ZERO <NRf>

This command initiates the offset adjustment of the dc current measurement.

Command Syntax	CALibrate:MEASure:CURRent:DC:ZERO
Parameters	<NRf> (0 or desired offset value)
Examples	CAL:MEAS:CURR:DC:ZERO
Query Syntax	CALibrate:MEASure:CURRent:DC:ZERO?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:CURRent:DC[:FSCale]

CALibrate:MEASure:POWer[:AC][:FSCale] <NRf>

This command initiates the calibration of the rms power measurement at full scale.

Command Syntax	CALibrate:MEASure:POWer
Parameters	<NRf> (actual load rms power measured with external device in Kwatt)
Examples	CAL:MEAS:POW 4.5
Query Syntax	CALibrate:MEASure:CURRent?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:POWer[:AC]:ZERO

CALibrate:MEASure:POWer[:AC]:ZERO <NRf>

This command initiates the offset adjustment of the rms power measurement.

Command Syntax	CALibrate:MEASure:POWer:ZERO
Parameters	<NRf> (0 or desired offset value)
Examples	CAL:MEAS:POW:ZERO 0
Query Syntax	CALibrate:MEASure:POW:ZERO?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:POWer[:AC][:FSCale]

CALibrate:MEASure:POWer:DC[:FSCale] <NRf>

This command initiates the calibration of the rms power measurement at full scale.

Command Syntax	CALibrate:MEASure:POWer:DC
Parameters	<NRf> (actual load dc power measured with external device in Kwatt)
Examples	CAL:MEAS:POW 4.5
Query Syntax	CALibrate:MEASure:POW?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:CURRent[:AC]:ZERO

CALibrate:MEASure:POWer:DC:ZERO <NRf>

This command initiates the offset adjustment of the rms power measurement.

Command Syntax	CALibrate:MEASure:POWer:DC:ZERO
Parameters	<NRf> (0 or desired offset value)
Examples	CAL:MEAS:POW:DC:ZERO 0
Query Syntax	CALibrate:MEASure:POW:DC:ZERO?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:POWer:DC[:FSCale]

CALibrate:MEASure:VOLTage[:AC][:FSCale] <NRf>

This command initiates the calibration of the rms voltage measurement at full scale.

Command Syntax	CALibrate:MEASure:VOLTage
Parameters	<NRf> (actual rms output voltage measured with external device)
Examples	CAL:MEAS:VOLT 120
Query Syntax	CALibrate:MEASure:VOLTage?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:VOLTage[:AC]:ZERO

CALibrate:MEASure:VOLTage[:AC]:ZERO <NRf>

This command initiates the offset adjustment of the rms voltage measurement.

Command Syntax	CALibrate:MEASure:VOLTage:ZERO
Parameters	<NRf> (0 or desired offset value)
Examples	CAL:MEAS:VOLT:ZERO 0
Query Syntax	CALibrate:MEASure:VOLT:ZERO?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:VOLTage[:AC][:FSCale]

CALibrate:MEASure:VOLTage:DC[:FSCale][:POSitive] <NRf>

This command initiates the calibration of the dc positive output voltage measurement at full scale.

Command Syntax	CALibrate:MEASure:VOLTage:DC
Parameters	<NRf> (actual dc positive voltage measured with external device in volt)
Examples	CAL:MEAS:VOLT:DC 100
Query Syntax	CALibrate:MEASure:VOLT:DC?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:VOLT:DC:ZERO

CALibrate:MEASure:VOLTage:DC[:FSCale]:NEGative] <NRf>

This command initiates the calibration of the dc negative output voltage measurement at full scale.

Command Syntax	CALibrate:MEASure:VOLTage:DC:NEGative
Parameters	<NRf> (actual dc negative voltage measured with external device in volt)
Examples	CAL:MEAS:VOLT:DC:NEG -100
Query Syntax	CALibrate:MEASure:VOLT:DC:NEG?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:VOLT:DC:ZERO

CALibrate:MEASure:VOLT:DC:ZERO <NRf>

This command initiates the offset adjustment of the dc volt measurement.

Command Syntax	CALibrate:MEASure:VOLTage:DC:ZERO
Parameters	<NRf> (0 or desired offset value)
Examples	CAL:MEAS:VOLT:DC:ZERO 0
Query Syntax	CALibrate:MEASure:VOLT:DC:ZERO?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	CALibrate:MEASure:VOLT:DC[:FSCale]

CALibrate[:SOURce]:VOLTage[:AC]:LRANge[:FSCale] <NRf+>

This command will set the calibration coefficent for the AC full scale output voltage at the low voltage range.

Command Syntax	CALibrate:VOLTage:LRANge <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:LRAN -2
Query Syntax	CALibrate:VOLTage:LRANge?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

CALibrate[:SOURce]:VOLTage[:AC]:LRANge:ZERO <NRf+>

This command will set the calibration coefficent for the output voltage offset at the low voltage range.

Command Syntax	CALibrate:VOLTage:LRANge:ZERO <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:LRAN:ZERO +10
Query Syntax	CALibrate:VOLTage:LRANge:ZERO?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

CALibrate[:SOURce]:VOLTage[:AC]:LRANge:HFRequency <NRf+>

This command will set the calibration coefficent for the AC full scale output voltage at the low voltage range and at high output frequency

Command Syntax	CALibrate:VOLTage:LRANge:HFRequency <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:LRAN:HFRequency +10
Query Syntax	CALibrate:VOLTage:LRANge:HFRequency?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

CALibrate[:SOURce]:VOLTage[:AC]:HRANge[:FSCale] <NRf+>

This command will set the calibration coefficent for the AC full scale output voltage at the high voltage range.

Command Syntax	CALibrate:VOLTage:HRANge <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:HRAN -2
Query Syntax	CALibrate:VOLTage:HRANge?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

CALibrate[:SOURce]:VOLTage[:AC]:HRANge:ZERO <NRf+>

This command will set the calibration coefficent for the output voltage offset at the high voltage range.

Command Syntax	CALibrate:VOLTage:HRANge:ZERO <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:HRAN:ZERO +10
Query Syntax	CALibrate:VOLTage:HRANge:ZERO?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

CALibrate[:SOURce]:VOLTage[:AC]:HRANge:HFRequency <NRf+>

This command will set the calibration coefficent for the AC full scale output voltage at the high voltage range and at high output frequency

Command Syntax	CALibrate:VOLTage:HRANge:HFRequency <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:HRAN:HFRequency +10
Query Syntax	CALibrate:VOLTage:HRANge:HFRequency?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

CALibrate[:SOURce]:VOLTage:DC:LRANge[:FSCale] [:POSitive] <NRf+>

This command will set the calibration coefficent for the positive dc full scale output voltage at the low voltage range.

Command Syntax	CALibrate:VOLTage:DC:LRANge <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:DC:LRAN -2
Query Syntax	CALibrate:VOLTage:DC:LRANge?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

CALibrate[:SOURce]:VOLTage:DC:LRANge[:FSCale] :NEGative <NRf+>

This command will set the calibration coefficent for the negative dc full scale output voltage at the low voltage range.

Command Syntax	CALibrate:VOLTage:DC:LRANge <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:DC:LRAN -2
Query Syntax	CALibrate:VOLTage:DC:LRANge?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

CALibrate[:SOURce]:VOLTage:DC:LRANge:ZERO <NRf+>

This command will set the calibration coefficent for the dc output voltage offset at the low voltage range.

Command Syntax	CALibrate:VOLTage:DC:LRANge:ZERO <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:DC:LRAN:ZERO +10
Query Syntax	CALibrate:VOLTage:DC:LRANge:ZERO?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

CALibrate[:SOURce]:VOLTage:DC:HRANge[:FSCale] [:POSitive] <NRf+>

This command will set the calibration coefficent for the positive dc full scale output voltage at the high voltage range.

Command Syntax	CALibrate:VOLTage:DC:HRANge <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:DC:HRAN -2
Query Syntax	CALibrate:VOLTage:DCHRANge?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

CALibrate[:SOURce]:VOLTage:DC:HRANge[:FSCale] :NEGative <NRf+>

This command will set the calibration coefficent for the negative dc full scale output voltage at the high voltage range.

Command Syntax	CALibrate:VOLTage:DC:HRANge <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:DC:LRAN -2
Query Syntax	CALibrate:VOLTage:DC:LRANge?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

CALibrate[:SOURce]:VOLTage:DC:HRANge:ZERO <NRf+>

This command will set the calibration coefficent for the dc output voltage offset at the high voltage range.

Command Syntax	CALibrate:VOLTage:DC:HRANge:ZERO <NRf+>
Parameters	<NRf> (a value between -127 and +128)
Examples	CAL:VOLT:DC:HRAN:ZERO +10
Query Syntax	CALibrate:VOLTage:DC:HRANge:ZERO?
Returned Parameters	<NR1> (value range -127 to +128)
Related Commands	

4.2.2 Current Measurement Subsystem

This subsystem programs the current measurement capability of the i Series source.

Subsystem Syntax

```
MEASure
    [:SCALar]
        :CURRent
            [:AC]?  Returns AC component of the current
            :DC?    Returns dc rms current
            :AMPLitude
                :MAX?          Returns peak current
                :RESet         Reset the peak current measurement.
            :CRESTfactor?      Returns current crestfactor
```

MEASure:CURRent?

This query returns the rms value of the output AC current being sourced at the output terminals.

Query Syntax	MEASure[:SCALar]:CURRent[:AC]?
Parameters	None
Examples	MEAS:CURR?
Returned Parameters	<NR2>
Related Commands	none

MEASure:CURRent:DC?

This query returns the DC current component being sourced at the output terminals.

Query Syntax	MEASure[:SCALar]:CURRent:DC?
Parameters	None
Examples	MEAS:CURR:AC?
Returned Parameters	<NR2>
Related Commands	none

MEASure:CURRent:AMPLitude:MAXimum?

This query returns the absolute value of the peak current measurement.

Query Syntax	MEASure[:SCALar]:CURRent:AMPLitude:MAXimum?
Parameters	None
Examples	MEAS:CURR:AMPL:MAX?
Returned Parameters	<NR2>
Related Commands	MEAS:CURR:AMPL:RESet

MEASure:CURRent:AMPLitude:RESet

This command will reset the peak current measurement to zero.

Query Syntax	MEASure[:SCALar]:CURRent:AMPLitude:RESset.
Parameters	None
Examples	MEAS:CURR:AMPL:RES
Returned Parameters	None
Related Commands	MEAS:CURR:AMPL:MAX?

MEASure:CURRent:CREStfactor?

This query returns the output current crest factor. This is the ratio of peak output current to rms output current.

Query Syntax	MEASure[:SCALar]:CURRent:CREStfactor?
Parameters	None
Examples	MEAS:CURR:CRES?
Returned Parameters	<NR2>
Related Commands	None

4.2.3 Frequency Measurement Subsystem

This subsystem programs the frequency measurement capability of the i Series source.

Subsystem Syntax

```
MEASure
    [:SCALar]
        :FREQuency?          Returns the output frequency
```

MEASure:FREQuency?

This query returns the output frequency in Hertz.

Query Syntax	MEASure[:SCALar]:FREQuency?
Parameters	None
Examples	MEAS:FREQ?
Returned Parameters	<NR2>

4.2.4 Power Measurement Subsystem

This subsystem programs the power measurement capability of the i Series source.

Subsystem Syntax

```
MEASure
    [:SCALar]
        :POWer
            [:AC]
                [:REAL]?        Returns real power
                :APPArent?      Returns VA
                PFACtor?        Returns power factor
            :DC                 Return the dc component of power measuremnet
```

MEASure:POWer:AC?

This query returns the in-phase component of power being sourced at the output terminals in Kwatts.

Query Syntax	MEASure[:SCALar]:POWer[:AC][:REAL]?
Parameters	None
Examples	MEAS:POW:AC?
Returned Parameters	<NR2>
Related Commands	None

MEASure:POWer:AC:APParent? FETCh:POWer[:AC]:APParent?

This query returns the apparent power being sourced at the output terminals in Kvolt-amperes.

Query Syntax	MEASure[:SCALar]:POWer[:AC]:APParent?
Parameters	None
Examples	MEAS:POW:AC:APP?
Returned Parameters	<NR2>
Related Commands	None

MEASure:POWer:AC:PFACtor? FETCh:POWer[:AC]:PFACtor?

This query returns the output power factor. The power factor is computed as:

pfactor = real power/apparent power

Query Syntax	MEASure[:SCALar]:POWer[:AC]:PFACtor?
Parameters	None
Examples	MEAS:POW:PFAC?
Returned Parameters	<NR2>
Related Commands	None

MEASure:POWer:DC?

This query returns the DC component of the power being sourced at the output terminals in watts.

Query Syntax	MEASure[:SCALar]:POWer:DC?
Parameters	None
Examples	MEAS:POW?
Returned Parameters	<NR2>
Related Commands	None

4.2.5 Voltage Measurement Subsystem

This subsystem programs the voltage measurement capability of the i Series source.

Subsystem Syntax

```
MEASure
    [:SCALar]
        :VOLTage
            :DC?   Returns the dc component of the voltage
            [:AC]                    Returns AC rms voltage
```

MEASure:VOLTage:DC?

This query returns the DC component of the output voltage being sourced at the output terminals.

Query Syntax	MEASure[:SCALar]:VOLTage[:DC]?
Parameters	None
Examples	MEAS:VOLT:DC?
Returned Parameters	<NR2>
Related Commands	None

MEASure:VOLTage[:AC]?

This query returns the AC rms voltage being sourced at the output terminals.

Query Syntax	MEASure[:SCALar]:VOLTage[:AC]?
Parameters	None
Examples	MEAS:VOLT[:AC]?
Returned Parameters	<NR2>
Related Commands	None

4.2.6 Output Subsystem

This subsystem controls the main outputs, the signal outputs, the power-on state, and the output protection function of the i Series source.

Subsystem Syntax

```
OUTPut
    [:STATe] <bool>          Enable/disable output voltage, current, power, etc.
    :TTLTrg
        [:STATe] <bool>      Enable/disable trigger out drive
        :SOURce <source>     Selects a TTLTrg source (BOT|EOT|LIST)
```

OUTPut[:STATe]

This command enables or disables the source output. The state of a disabled output is an output voltage amplitude set to 0 volts, with output relays opened.

The query form returns the output state.

Command Syntax	OUTPut[:STATe]<bool>
Parameters	0 | OFF | 1 | ON
*RST Value	OFF
Examples	OUTP 1 OUTP:STAT ON
Query Syntax	OUTPut[:STATe]?
Returned Parameters	0 | 1
Related Commands	*RCL *SAV

OUTPut:TTLTrg

This command enables or disables the Trigger Out signal, which is available at the system interface connector on the rear panel of the i Series source.

Command Syntax	OUTPut:TTLTrg[:STATe]<bool>
Parameters	0|1|OFF|ON
*RST Value	OFF
Examples	OUTP:TTLT 1 OUTP:TTLT OFF
Query Syntax	OUTPut:TTLTrg[:STATe]?
Returned Parameters	0 | 1
Related Commands	OUTP:TTLT:SOUR

OUTPut:TTLTrg:SOURce

This command selects the signal source for the Trig Out signal as follows:

- BOT Beginning of transient output
- EOT End of transient output
- LIST Specified by the TTLTrg list

When an event becomes true at the selected TTLTrg source, a pulse is sent to the BNC connector on the rear panel of the i Series source.

Command Syntax	OUTPut:TTLTrg:SOURce<source>
Parameters	BOT|EOT|LIST
*RST Value	BOT
Examples	OUTP:TTLT:SOUR LIST
Query Syntax	OUTPut:TTLTrg:SOURce?
Returned Parameters	<CRD>
Related Commands	OUTP:TTLT

4.2.7 Source Subsystem - Current

This subsystem programs the output current of the i Series source.

Subsystem Syntax

```
[SOURce:]
    CURRent
        [:LEVel]
            [:IMMediate]
                [:AMPLitude] <n>        Sets the rms current limit
        :PROTection
            :STATe <bool>               Select rms current limit protection mode
            :DELay                      Set the delay in seconds before protection is
                                        enabled
```

CURRent

This command sets the rms current limit of the output. If the output current exceeds this limit, the output voltage amplitude is reduced until the rms current is within the limit if the current protection mode is disabled and the current protection delay time is expired. The CL bit of the questionable status register indicates that the current limit control loop is active. If the current protection state is programmed on, the output latches into a disabled state when current limiting occurs and the current protection delay time is expired.

Note that the CURRent command is coupled with the VOLTage:RANGe and SOURce:MODE. This means that the maximum current limit that can be programmed at a given time depends on the voltage range setting and the voltage mode (DC or AC) in which the unit is presently operating.

Command Syntax	[SOURce:]CURRent[:LEVel] [:IMMediate][:AMPLitude]<NRf+>
Parameters	<NR2>
Unit	A (rms amperes)
*RST	Defined by the PONSetup:CURRent
Examples	CURR 5CURR:LEV .5
Query Syntax	[SOURce:]CURRent[:LEVel] [:IMMediate][:AMPLitude]?
Returned Parameters	<NR3>
Related Commands	CURR:PROT:STAT VOLT:RANG MODE

CURRent:PROTection:STATe

This command selects overcurrent (OC) protection mode. If the overcurrent protection function is enabled and the load current exceeds the programmed level, then the output is disabled after a time delay specified by the CURRent:PROTection:DELay and the Questionable Condition status register OC bit is set (see chapter 6). An overcurrent condition is cleared after the cause of the condition is removed.

If the (OC) protection mode is disabled, the source operates in the Constant Current mode and the output voltage will be reduced after a time delay specified by the CURRent:PROTection:DELay and the Questionable Condition status register OC bit is set. (see chapter 6). An overcurrent condition is cleared after the cause of the condition is removed.

Use CURRent:PROT:DEL to prevent momentary current limit conditions caused by programmed output changes or load changes from tripping the overcurrent protection.

Command Syntax	[SOURce:]CURRent:PROTection:STATe<bool>
Parameters	0|1|OFF|ON
*RST Value	ON
Examples	CURR:PROT:STAT 0 CURR:PROT:STAT OFF
Query Syntax	[SOURce:]CURRent:PROTection:STATe?
Returned Parameters	0 | 1
Related Commands	OUTP:PROT:DEL

CURRent:PROTection:DELay

This command sets the delay time between over current limit condition and the response to this condition. At the end of the delay, if the over current condition still exist, the response will depend on the protection state.

If the protection state is on, the output voltage will fault to zero voltage. If the protection state is off, the output voltage will reduced to a value that maintains a constant current defined by the setting of the current limit.

Command Syntax	[SOURCE:] CURRent: PROTection:DELay
Parameters	0.1 to 5
Unit	seconds
*RST Value	100 milliseconds
Examples	CURR:PROT:DEL 1.5
Query Syntax	CURR:PROT:DEL?
Returned Parameters	<NR2>
Related Commands	OUTP:PROT:STATE

4.2.8 Source Subsystem - Frequency

This subsystem programs the output frequency of the i Series source.

Subsystem Syntax

```
[SOURce:]
    FREQuency
        :IMMediate] <n>                 Sets the frequency
        :MODE <mode>                    Sets frequency mode (FIX|STEP|PULS|LIST)
        :SLEW
        [:IMMediate] <n> | INFinity     Sets the frequency slew rate
        :MODE <mode>                    Sets frequency slew mode (FIX|STEP|PULS|LIST)
        :TRIGgered <n> | INFinity       Sets the triggered frequency slew rate
        :TRIGgered <n>                  Sets the triggered frequency
```

FREQuency

This command sets the frequency of the output waveform.

Command Syntax	[SOURce:]FREQuency[:CW|:IMMediate] <NRf+>
Parameters	Refer to specifications table in User Guide
Unit	Hz (Hertz)
*RST Value	60 Hz
Examples	FREQ 50
Query Syntax	[SOURce:]FREQuency?
Returned Parameters	<NR3>
Related Commands	FREQ:MODE FREQ:SLEW

FREQuency:MODE

This command determines how the output frequency is controlled during a triggered output transient. The choices are:

FIXed	The output frequency is unaffected by a triggered output transient.
STEP	The output frequency is programmed to the value set by FREQuency:TRIGgered when a triggered transient occurs.
PULSe	The output frequency is changed to the value set by FREQuency:TRIGgered for a duration determined by the pulse commands.
LIST	The output frequency is controlled by the frequency list when a triggered transient occurs.
SENSe	Selects external sync mode.
EXTernal	Selects external clock input.

Command Syntax	[SOURce:]FREQuency:MODE <mode>
Parameters	FIXed | STEP | PULSe | LIST|SENSe|EXT
*RST Value	FIXed
Examples	FREQ:MODE FIX
Query Syntax	[SOURce:]FREQuency:MODE?
Returned Parameters	<CRD>
Related Commands	FREQ FREQ:TRIG

FREQuency:SLEW

This command sets the rate at which frequency changes for all programmed changes in output frequency. Instantaneous frequency changes can be obtained by sending MAXimum.

Command Syntax	[SOURce:]FREQuency:SLEW[:IMMediate] <NRf+>
Parameters	0.01 to 1E9 | MAXimum
Unit	Hz (Hertz per second)
*RST Value	MAXimum
Examples	FREQ:SLEW:IMM 75FREQ:SLEW MAX
Query Syntax	[SOURce:]FREQuency:SLEW?
Returned Parameters	<NRf>
Related Commands	FREQ:SLEW:MODE FREQ

FREQuency:SLEW:MODE

This command determines how the frequency slew rate is controlled during a triggered output transient. The choices are:

FIXed	The frequency slew rate is unaffected by a triggered output transient.
STEP	The frequency slew rate is programmed to the value set by FREQuency:TRIGgered when a triggered transient occurs.
PULSe	The frequency slew rate is changed to the value set by FREQuency:TRIGgered for a duration determined by the pulse commands.
LIST	The frequency slew rate is controlled by the frequency list when a triggered transient occurs.

Command Syntax	[SOURce:]FREQuency:SLEW:MODE<mode>
Parameters	FIXed | STEP | PULSe | LIST
*RST Value	FIXed
Examples	FREQ:SLEW:MODE FIX
Query Syntax	[SOURce:]FREQuency:SLEW:MODE?
Returned Parameters	<CRD>
Related Commands	FREQ FREQ:SLEW:TRIG

FREQuency:SLEW:TRIGgered

This command sets the rate at which frequency changes during a triggered output transient. Instantaneous frequency changes can be obtained by sending MAXimum.

Command Syntax	[SOURce:]FREQuency:SLEW:TRIGgered <NRf+>
Parameters	0.01 to 1E9 | MAXimum
Unit	Hz (Hertz per second)
*RST Value	MAXimum
Examples	FREQ:SLEW:TRIG 75 FREQ:SLEW:TRIG MAX
Query Syntax	[SOURce:]FREQuency:SLEW:TRIG?
Returned Parameters	<NRf>
Related Commands	FREQ:SLEW:MODE FREQ

FREQuency:TRIGgered

This command programs the frequency that the output will be set to during a triggered step or pulse transient.

Command Syntax	[SOURce:]FREQuency:TRIGgered <NRf+>
Parameters	0 to maximum frequency range specified by the LIMit:FREQuency command
Unit	Hz (Hertz)
*RST Value	60 Hz
Example	FREQ:TRIG 50
Query Syntax	[SOURce:]FREQuency:TRIGgered?
Returned Parameters	<NR2>
Related Commands	FREQ FREQ:MODE

4.2.9 Source subsystem - Limit

This subsystem controls the voltage frequency and current limit of the power source. These limits are set at the factory and depends on the power source rating. It is not accessable by the user. The query format is accessable however.

Subsystem Syntax

```
[SOURce:]
    LIMit
        FREQuency <n1>,<n2>
        VOLTage <n>
        CURRent <n>
```

LIMit:FREQuency

This command sets the upper and lower frequncy limit of the power source

Command Syntax	[SOURce:]LIMit:FREQuency <NRf> , <NRf>
Parameters	low freq limit, upper frequency limit [command protected]
Query Syntax	[SOURce:]LIMit:FREQuency?
Returned Parameters	<NR2>, <NR2>

LIMit:CURRent

This command will set the maximum current limit the power source will operate at in the low voltage range.

Command Syntax	[SOURce:]LIMit:CURRent <NRf>
Parameters	maximum current limit at low voltage range [command protected]
Query Syntax	[SOURce:]LIMit:FREQuency?
Returned Parameters	<NR2>

LIMit:VOLTage

This command will set the maximum voltage the power source will operate at in the high voltage range.

Command Syntax	[SOURce:]LIMit:VOLTage<NRf>
Parameters	maximum current limit at low voltage range [command protected]
Query Syntax	[SOURce:]LIMit:FREQuency?
Returned Parameters	<NR2>

4.2.10 Source Subsystem - List

This subsystem controls the generation of complex sequences of output changes with rapid, precise timing and synchronized with internal or external signals. Each subsystem command for which lists can be generated has an associated list of values that specify the output at each list step. LIST:COUNt determines how many times the source sequences through a list before that list is completed. LIST:REPeat determines how many times each data point will repeat. LIST:DWELl specifies the time interval that each value (point) of a list is to remain in effect. LIST:STEP detemines if a trigger causes a list to advance only to its next point or to sequence through all of its points.

All active subsystems that have their modes set to LIST must have the same number of points (up to 32), or an error is generated when the first list point is triggered. The only exception is a list consisting of only one point. Such a list is treated as if it had the same number of points as the other lists, with all of the implied points having the same value as the one specified point.

MODE commands such as VOLTage:MODE LIST are used to activate lists for specific functions. However, the LIST:DWELl command is active whenever any function is set to list mode. Therefore, LIST:DWELl must always be set either to one point, or to the same number of points as the active list.

Subsystem Syntax

[SOURce:]	
LIST	
:COUNt <n> | INFinity	Sets the list repeat count
:CURRent <n> ,<n>	Sets the peak current limit list
:POINts?	Returns the number of peak current limit list points
:DWELl <n> ,<n>	Sets the list of dwell times
:POINts?	Returns the number of dwell list points
:FREQuency	
[:LEVel] <n> ,<n>	Sets the frequency list
:POINts?	Returns the number of frequency points
:SLEW <n> ,<n>	Sets the frequency slew list
:POINts?	Returns the number of frequency slew points
:REPeat	
[:COUNt] <n>,<n>	Set the repeat count for each data points.
:POINts	Returns the number of repeat for each data points
:STEP ONCE | AUTO	Defines whether list is dwell- or trigger-paced
:TTLTrg <bool> ,<bool>	Defines the output marker list
:POINts?	Returns the number of output marker list points
:VOLTage	
[:LEVel] <n> ,<n>	Sets the voltage list
:POINts?	Returns the number of voltage level points
:SLEW <n> ,<n>	Sets the voltage slew list
:POINts?	Returns the number of voltage slew points

LIST:COUNt

This command sets the number of times that the list is executed before it is completed. The command accepts parameters in the range 1 through 2E8.

Command Syntax	[SOURce:]LIST:COUNt<NRf+>
Parameters	1 to 2E8 | MINimum | MAXimum
*RST Value	1
Examples	LIST:COUN 3
	LIST:COUN MAX
Query Syntax	[SOURce:]LIST:COUNt?
Returned Parameters	<NRf>
Related Commands	LIST:FREQ
	LIST:TTLT
	LIST:VOLT

LIST:DWELI

This command sets the sequence of list dwell times. Each value represents the time in seconds that the output will remain at the particular list step point before completing the step. At the end of the dwell time, the output of the source depends upon the following conditions:

- If LIST:STEP AUTO has been programmed, the output automatically changes to the next point in the list.
- If LIST:STEP ONCE has been programmed, the output remains at the present level until a trigger sequences the next point in the list.

The order in which the points are entered determines the sequence in which they are output when a list is triggered.

Command Syntax	[SOURce:]LIST:DWELI<NRf+>
	,<NRf+>
Parameters	0.001 to 9E4|MINimum|MAXimum
Unit	S (seconds)
Examples	LIST:DWEL .1,.5,1.5
Query Syntax	[SOURce:]LIST:DWEL?
Returned Parameters	<NR2>
Related Commands	LIST:FREQ
	LIST:TTLT
	LIST:VOLT

LIST:DWELI:POINts?

This query returns the number of points specified in LIST:DWELI. Note that it returns only the total number of points, not the point values.

Query Syntax	[SOURce:]LIST:DWELI:POINts?
Returned Parameters	<NR1>
Example	LIST:DWEL:POIN?
Related Commands	LIST:DWELI

LIST:FREQuency

This command sets the sequence of frequency list points. The frequency points are given in the command parameters, which are separated by commas.

The order in which the points are entered determines the sequence in which they are output when a list is triggered.

Command Syntax	[SOURce:]LIST:FREQuency[:LEVel]<NRf+>,<NRf+>
Parameters	Values limited to the frequency range
Unit	HZ (Hertz)
Examples	LIST:FREQ 60,65,70
Query Syntax	[SOURce:]LIST:FREQ?
Returned Parameters	<NR2>
Related Commands	LIST:FREQ:POIN?
	LIST:COUN
	LIST:DWEL
	LIST:STEP
	LIST:FREQ:SLEW

LIST:FREQuency:POINts?

This query returns the number of points specified in LIST:FREQuency. Note that it returns only the total number of points, not the point values.

Query Syntax	[SOURce:]LIST:FREQ[:LEVel]:POINts?
Returned Parameters	<NR1>
Example	LIST:FREQ:POIN?
Related Commands	LIST:FREQ

LIST:FREQuency:SLEW

This command sets the sequence of frequency slew list points. The frequency points are given in the command parameters, which are separated by commas.The order in which the points are entered determines the sequence in which they are output when a list is triggered.

Command Syntax	[SOURce:]LIST:FREQuency:SLEW<NRf+>,<NRf+>
Parameters	0.01 to 1E9 | MAXimum
Unit	HZ (Hertz) per second
Examples	LIST:FREQ:SLEW 10, 1E2, MAX
Query Syntax	[SOURce:]LIST:FREQ:SLEW?
Returned Parameters	<NR3>
Related Commands	LIST:FREQ:SLEW:POIN?
	LIST:COUNLIST:DWEL
	LIST:STEP
	LIST:FREQ

LIST:FREQuency:SLEW:POINts?

This query returns the number of points specified in LIST:FREQuency:SLEW. Note that it returns only the total number of points, not the point values.

Query Syntax	[SOURce:]LIST:FREQ:SLEW:POINts?
Returned Parameters	<NR1>
Example	LIST:FREQ:SLEW:POIN?
Related Commands	LIST:FREQ:SLEW

LIST:REPeat[:COUNt]

This command sets the sequence of repeat values for each data list point. The repeat values are given in the command parameters, which are separated by commas.The order in which the points are entered determines the sequence in which they are repeated when a list is triggered.

Command Syntax	[SOURce:]LIST:REPeat[:COUNt] <NRf+>,<NRf+>
Parameters	0 to 99
Examples	LIST:REPeat 1,0,5
Query Syntax	[SOURce:]LIST:REPeat?
Returned Parameters	<NR1>
Related Commands	LIST:PHAS:POIN? LIST:COUNLIST:DWELLIST:STEP

LIST:REPeat:POINts?

This query returns the number of points specified in LIST:REPeat. Note that it returns only the total number of points, not the point values.

Query Syntax	SOURce:]LIST:PHASe:POINts?
Returned Parameters	<NR1>
Example	IST:PHAS:POIN?
Related Commands	IST:FREQ LIST:DWEL

LIST:STEP

This command specifies how the list sequencing responds to triggers.

- ONCE causes the list to advance only one point after each trigger. Triggers that arrive during a dwell delay are ignored.
- AUTO causes the entire list to be output sequentially after the starting trigger, paced by its dwell delays. As each dwell delay elapses, the next point is immediately output.

Command Syntax	[SOURce:]LIST:STEP<step>
Parameters	ONCE | AUTO
*RST Value	AUTO
Examples	LIST:STEP ONCE
Query Syntax	[SOURce:]LIST:STEP?
Returned Parameters	<CRD>
Related Commands	LIST:COUN LIST:DWEL

LIST:TTLTrg

This command sets the sequence of Trigger Out list points. Each point which is set ON will cause a pulse to be output at Trigger Out when that list step is reached. Those entries which are set OFF will not generate Trigger Out pulses. The order in which the list points are given determines the sequence in which Trigger Out pulses will be output when a list transient is triggered.

Command Syntax	[SOURce:]LIST:TTLTrg<bool> ,<bool>
Parameters	0|1|OFF|ON
Examples	LIST:TTLT 1,0,1 LIST:TTLT ON,OFF,ON
Query Syntax	LIST:TTLT?
Returned Parameters	0 | 1
Related Commands	LIST:TTLT:POIN? LIST:COUN LIST:DWELLIST:STEP OUTP:TTLT:STAT OUTP:TTLT:SOUR

LIST:TTLTrg:POINts?

This query returns the number of points specified in LIST:TTLT. Note that it returns only the total number of points, not the point values.

Query Syntax	[SOURce:]LIST:TTLTrg:POINts?
Returned Parameters	<NR1>
Example	LIST:TTLT:POIN?
Related Commands	LIST:TTLT

LIST:VOLTage

This command specifies the output voltage points in a list. The voltage points are given in the command parameters, which are separated by commas. The order in which the points are entered determines the sequence in which the list will be output when a list transient is triggered.

Command Syntax	[SOURce:]LIST:VOLTage[:LEVel] <NRf+>,<NRf+>
Parameters	Value depends on the voltage range and the voltage mode
Unit	V (rms voltage)
Examples	LIST:VOLT 2.0,2.5,3.0 LIST:VOLT MAX,2.5,MIN
Query Syntax	[SOURce:]LIST:VOLTage[:LEVel]?
Returned Parameters	<NR2>
Related Commands	LIST:VOLT:POIN? LIST:COUN LIST:DWELLIST:STEP LIST:SHAP LIST:VOLT:OFFS

LIST:VOLTage:POINts?

This query returns the number of points specified in LIST:VOLT. Note that it returns only the total number of points, not the point values.

Query Syntax	[SOURce:]LIST:VOLTage:POINts?
Returned Parameters	<NR1>
Example	LIST:VOLT:POIN?
Related Commands	LIST:VOLT

LIST:VOLTage:SLEW

This command specifies the output offset slew points in a list. The slew points are given in the command parameters, which are separated by commas. The order in which the points are entered determines the sequence in which the list will be output when a list transient is triggered. Changing list data while a subsystem is in list mode generates an implied ABORt.

Command Syntax	[SOURce:]LIST:VOLTage:SLEW <NRf+>,<NRf+>
Parameters	0.1 to 1E9 | MAX
Unit	V/S (volts per second)
Example	LIST:VOLT:SLEW 10, 1E2, MAX
Query Syntax	[SOURce:]LIST:VOLTage:SLEW?
Returned Parameters	<NR3>
Related Commands	LIST:VOLT:SLEW:POIN? LIST:COUN LIST:DWELLIST:STEP

LIST:VOLTage:SLEW:POINts?

This query returns the number of points specified in LIST:VOLTage:SLEW. Note that it returns only the total number of points, not the point values.

Query Syntax	[SOURce:]LIST:VOLTage:SLEW:POINts?
Returned Parameters	<NR1>
Example	LIST:VOLT:SLEW:POIN?
Related Commands	LIST:VOLT:SLEW

4.2.11 Source Subsystem - Phase

This subsystem programs the output phase angle of the AC/DC source. When phase command is used to program single-phase units, the only discernible effect in using the phase commands is to cause an instantaneous shift in the output waveform phase relative to an external reference signal.

Subsystem Syntax

```
[SOURce:]
    PHASe
        [:IMMediate] <n>          Sets the output phase
```

PHASe

This commands sets the phase of the output voltage waveform relative to an external reference. The phase angle is programmed in degrees. Positive phase angles are used to program the leading phase, and negative phase angles are used to program the lagging phase.

Command Syntax	[SOURce:]PHASe[:IMMediate] <NRf+>
Parameters	-360 through +360
*RST Value	Define by the PONSetup:PHASe
Examples	PHAS 45
Query Syntax	[SOURce:]PHASe?
Returned Parameters	<NR2>

4.2.12 Source Subsystem PONSetup

This subsystem will control the initial condition of the power source at the power on state.

Subsystem syntax

[SOURce:]	
PONSetup:	
FREQuency <n>	Set the frequency value
VOLTage	
[:LEVel] <n>	Set the voltage level
MODE DC|AC	Set the voltage mode
CURRent <n>	Set the current limit
PHASe	
[:ANGLe]	Set the phase angle relative to external
VRANge 135|270	Set the voltage range
LANGuage SCPI|APE|LAST	Set the command language
OUTPut	
[:RELay] 0|1|OFF|ON	Set the state of the output relay
OLOad	
[:MODE] CVOLT|CCURR	Set the over load mode const voltage or const current

PONSetup:FREQuency

This command sets the initial frequency of the power source at the power on.

Command Syntax	[SOURce:]PONSetup:FREQuncy <NRf+>
Parameters	set by the LIMit:FREQuency
Examples	PONS:FREQ 50
Query Syntax	PONS:FREQ?
Returned Parameters	<NR2>

PONSetup:VOLTage[:LEVel]

This command sets the output voltage level at the power on. This voltage level can not exceed the limit at the initial voltage range.

Command Syntax	[SOURce:]PONSetup:VOLTage[:LEVel] <NRf+>
Parameters	set by the LIMit:VOLTage and voltage mode AC or DC
Examples	PONS:VOLT 0
Query Syntax	PONS:VOLT?
Returned Parameters	<NR2>

PONSetup:VOLTage:MODE

This command sets the initial voltage mode at the power on. This mode is DC or AC

Command Syntax	[SOURce:]PONSetup: VOLTage:MODE
Parameters	AC|DC
Examples	PONS: VOLTage:MODE DC
Query Syntax	PONS: VOLTage:MODE?
Returned Parameters	<CRD>

PONSetup:CURRent

This command sets the initial current limit at the power on. The maximum allowable current is controlled by the voltage range and voltage mode.

Command Syntax	[SOURce:]PONSetup:CURRent <NRf+>
Parameters	range set by the LIMit:CURRent, voltage mode and voltage range
Examples	PONS:CURR 22
Query Syntax	PONS:CURR?
Returned Parameters	<NR2>

PONSetup:PHASe[:ANGLe]

This command sets the initial phase angle of the power source relative to external referance.

Command Syntax	[SOURce:]PONSetup:PHASe[:ANGLe <NRf+>
Parameters	± 360
Examples	PONS:PHAS 0
Query Syntax	PONS:PHAS
Returned Parameters	<NR2>

PONSetup:LANGuage

This command sets the interface language at power on. If SCPI is the only language avilable then LAST can not be selected.

Command Syntax	[SOURce:]PONSetup:LANGuage <selection>
Parameters	SCPI|APE|LAST
Examples	LANG SCPI
Query Syntax	PONS:LANG?
Returned Parameters	<CRD>

PONSetup:OUTPut[:RELay]

This command sets the initial state of the output relay at the power on.

Command Syntax	[SOURce:]PONSetup:OUTPut[:RELay <boolean>
Parameters	0|1|OFF|ON
Examples	OUTP ON OUTP 0
Query Syntax	PONS:OUTP?
Returned Parameters	0|1

PONSetup:OLOad[:MODE]

This command determines how the power source will react to an over current condition. In const current mode, the output voltage is reduced to a value that maintains a constant laod current. In constant voltage mode, the output faults to an initial value if the over current condition is maintained beyond the protection delay period.

Command Syntax	[SOURce:]PONSetup:OLOad[:MODE] <mode>
Parameters	CCURrent|CVOLTage
Examples	OLOad CCUR
Query Syntax	PONS:OLO?
Returned Parameters	<CRD>
Related Commands	CURR:PROT:STAT

4.2.13 Source Subsystem - Pulse

This subsystem controls the generation of output pulses. The PULSe:DCYCle, PULSe:PERiod, and PULSe:WIDTh commands are coupled, which means that the values programmed by any one of these commands can be affected by the settings of the others. Refer to the tables under PULSe:HOLD for an explanation of how these commands affect each other.

Subsystem Syntax

```
[SOURce:]
    PULSe
        :COUNt <n> | INFinity      Selects transient pulse count
        :DCYCle <n>                Selects pulse duty cycle
        :PERiod <n>                Selects pulse period when the count is greater than
                                   1
        :WIDTh <n>                 Selects width of the pulses
```

PULSe:COUNt

This command sets the number of pulses that are output when a triggered output transient occurs. The command accepts parameters in the range 1 through 2E8. If MAXimum is sent, the output pulse repeats indefinitely.

Command Syntax	[SOURce:]PULSe:COUNt<NRf+>
Parameters	1 to 2E8 | MINimum | MAXimum
*RST Value	1
Examples	PULS:COUN 3 PULS:COUN MIN PULS:COUN INF
Query Syntax	[SOURce:]PULS:COUNt?
Returned Parameters	<NR3>
Related Commands	PULS:DCYC PULS:PER PULS:WIDT

PULSe:DCYCle

This command sets the duty cycle of the triggered output pulse. The duty cycle units are specified in percent.

Command Syntax	[SOURce:]PULSe:DCYCle<NRf+>
Parameters	0 to 100%|MINimum|MAXimum
*RST Value	50%
Examples	PULS:DCYC 75 PULS:DCYC MAX
Query Syntax	[SOURce:]PULSe:DCYCle?
Returned Parameters	<NR3>
Related Commands	PULS:COUN PULS:PER PULS:WIDT

PULSe:PERiod

This command sets the period of a triggered output transient The command parameters are model-dependent.

Command Syntax	[SOURce:]PULSe:PERiod<NRf+>
Parameters	2 msecs to 90,000 secs|MINimum|MAXimum
Unit	S (seconds)
*RST Value	1 sec
Examples	PER 0.001PER MIN
Query Syntax	[SOURce:]PERiod?
Returned Parameters	<NR3>
Related Commands	PULS:COUN PULS:DCYC PULS:WIDT

PULSe:WIDTh

This command sets the width of a transient output pulse.The command parameters are model-dependent.

Command Syntax	[SOURce:]PULSe:WIDTh<NRf+>
Parameters	1 msecs to 90,000 secs |MINimum|MAXimum
Unit	S (seconds)
*RST Value	0.5 secs
Examples	PULS:WIDT 0.001PULS:WIDT MIN
Query Syntax	[SOURce:]PULSe:WIDTh?
Returned Parameters	<NR3>
Related Commands	PULS:COUN PULS:DCYC PULS:PER

4.2.14 Source Subsystem - Voltage

This subsystem programs the output voltage of the 5001i, 10001i and the 15001i.

Subsystem Syntax

```
[SOURce:]
    VOLTage
        [:LEVel]
            [:IMMediate]
                [:AMPLitude] <n>            Sets the AC rms voltage amplitude
                    [:AC]
                    :DC
            :TRIGgered
                [:AMPLitude] <n>            Sets the transient voltage amplitude
            :MODE <mode>                    Sets the voltage mode
                                            (FIX|STEP|PULS|LIST)
        :RANGe <n>                          Sets the voltage range
        :SENSe
            [:SOURce] INTernal | EXTernal   Sets voltage sense source
        :SLEW
            [:IMMediate] <n> | MAXimum      Sets the voltage slew rate
            :MODE <mode>                    Sets voltage slew mode
                                            (FIX|STEP|PULS|LIST)
            :TRIGgered
                [:AMPLitude] <n> | MAXimum
                        Sets the transient voltage slew rate
```

VOLTage

This command programs the AC rms or DC output voltage level of the power source.

Command Syntax	[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude][:AC] <NRf+> [SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]:DC] <NRf+>
Parameters	0 to maximum voltage range specified by the LIMit:VOLTage command
Unit	V (rms voltage)
*RST Value	0 volt
Examples	VOLT 250 VOLT:LEV 25
Query Syntax	[SOURce:]VOLTage[:LEVel][:IMMediate][:AMPLitude]?
Returned Parameters	<NR2>
Related Commands	VOLT:MODE VOLT:TRIG

VOLTage:TRIGgered

This command selects the AC rms or dc amplitude that the output volatge will be set to during a triggered step or pulse transient.

Command Syntax	SOURce:]VOLTage[:LEVel]:TRIGgered:AMPLitude]<NRf+>
Parameters	0 to maximum voltage range specified by the LIMit:VOLTage command
Unit	V (rms voltage)
*RST Value	0 volt
Examples	VOLT:TRIG 120 VOLT:LEV:TRIG 120
Query Syntax	SOURce:]VOLTage[:LEVel]:TRIGgered[:AMPLitude]?
Returned Parameters	<NR2>
Related Commands	VOLT VOLT:MODE

VOLTage:MODE

This command determines how the output voltage is controlled during a triggered output transient. The choices are:

FIXed	The voltage is unaffected by a triggered output transient.
STEP	The voltage is programmed to the value set by VOLTage:TRIGgered when a triggered transient occurs.
PULSe	The voltage is changed to the value set by VOLTage:TRIGgered for a duration determined by the pulse commands.
LIST	The voltage is controlled by the voltage list when a triggered transient occurs.

Command Syntax	[SOURce:]VOLTage:MODE<mode>
Parameters	FIXed | STEP | PULSe | LIST
*RST Value	FIX
Examples	VOLT:MODE LIST VOLT:MODE FIX
Query Syntax	[SOURce:]VOLTage:MODE?
Returned Parameters	<CRD>
Related Commands	VOLT:TRG VOLT

VOLTage:RANGe

This command sets the voltage range of the power source . Two voltage ranges are available: a 135 volt range and a 270 volt range. Sending a parameter other than 135 or 270 will not be accepted.

When the range is set to 135, the maximum rms voltage that can be programmed is 135 volts.

The VOLTage:RANGe command is coupled with the CURRent command.This means that the maximum current limit that can be programmed at a given time depends on the voltage range setting in which the unit is presently operating.

Command Syntax	[SOURce:]VOLTage:RANGe<NRf+>
Parameters	135 | 270
*RST Value	Defined by the PONSetup:RANGe
Examples	VOLT:RANG 135 VOLT:RANG MIN
Query Syntax	[SOURce:]VOLTage:RANGe?
Returned Parameters	<NR2>
Related Commands	VOLT

VOLTage:SENSe[:SOURce]

This command selects the source from which the output voltage is sensed. The following voltage sense sources can be selected:

INTernal	This senses the voltage at the output of the power amplifier on the in-board side of the output disconnect relay.
EXTernal	This senses the output voltage at the user's sense terminals, which allows remote voltage sensing at the load.

Command Syntax	[SOURce:]VOLTage:SENSe[:SOURce] <source>
Parameters	INTernal | EXTernal
*RST Value	INTernal
Examples	VOLT:SENS:SOUR INT
Query Syntax	[SOURce:]VOLTage:SENSe[:SOURce]?
Returned Parameters	<CRD>

VOLTage:SLEW

This command sets the slew rate for all programmed changes in the output voltage level of the source. A parameter of MAXimum will set the slew to its maximum possible rate. The SCPI representation for MAXimum is 1E9.

Command Syntax	[SOURce:]VOLTage:SLEW[:IMMediate]<NRf+>
Parameters	0 to1e9 | MAX
Unit	V/S (volts per second)
*RST Value	MAX
Examples	VOLT:SLEW 1 VOLT:SLEW MAX VOLT:SLEW INF
Query Syntax	[SOURce:]VOLTage:SLEW[:IMMediate]?
Returned Parameters	<NR3>
Related Commands	VOLT:SLEW:MODE VOLT:SLEW:TRIG

VOLTage:SLEW:MODE

This command determines how the output voltage slew rate is controlled during a triggered output transient. The choices are:

FIXed	The slew rate is unaffected by a triggered output transient.
STEP	The slew rate is programmed to the value set by VOLTage:SLEW:TRIGgered when a triggered transient occurs.
PULSe	The slew rate is changed to the value set by VOLTage:SLEW:TRIGgered for a duration determined by the pulse commands.
LIST	The slew rate is controlled by the voltage slew list when a triggered transient occurs.

Command Syntax	[SOURce:]VOLTage:SLEW:MODE<mode>
Parameters	FIXed | STEP | PULSe | LIST
*RST Value	FIX
Examples	VOLT:SLEW:MODE LIST VOLT:SLEW:MODE FIX
Query Syntax	[SOURce:]VOLTage:SLEW:MODE?
Returned Parameters	<CRD>
Related Commands	VOLT:SLEW:TRG VOLT:SLEW

VOLTage:SLEW:TRIGgered

This command selects the slew rate that will be set during a triggered step or pulse transient. A parameter of MAXimum will set the slew to its maximum possible rate. The representation for maximum is1E9

Command Syntax	[SOURce:]VOLTage:SLEW:TRIGgered<NRf+>
Parameters	0 to 1E9 | MAXimum
Unit	V/S (volts per second)
*RST Value	MAXimum
Examples	VOLT:SLEW:TRIG 1 VOLT:SLEW:TRIG MAX VOLT:SLEW:TRIG INF
Query Syntax	[SOURce:]VOLTage:SLEW:TRIGgered?
Returned Parameters	<NR3>
Related Commands	VOLT:SLEW:MODE VOLT:SLEW

4.2.15 Status Subsystem Commands

This subsystem programs the i Series status registers. There are four

groups of status registers; **Operation**, **Questionable**, **Questionable Instrument ISummary** and **Standard Event**. The Standard Event group is programmed with Common commands. The Operation, Questionable, and Instrument ISummary status groups each consist of the following three registers:

Condition	Enable	Event

Refer to chapter 6 for more information about the status registers.

Subsystem Syntax

STATus
:OPERation
:EVENt — Returns the value of the event register
:CONDition — Returns the value of the condition register
:ENABle <n> — Enables specific bits in the Event register
:QUEStionable
:EVENt — Returns the value of the event register
:CONDition — Returns the value of the condition register
:ENABle <n> — Enables specific bits in the Event register

Bit Configuration of Status Operation Registers

Bit Position	**15-5**	**4**	**3**	**1-2**	**0**
Bit Name	not used	MEAS	TRANS	not used	CAL
Bit Weight		16	8		1

CAL	Calibration is completed
TRANS	Transient is completed
MEAS	Measurement is completed

STATus:OPERation:EVENt?

This query returns the value of the Operation Event register. The Event register is a read-only register which holds (latches) all events. Reading the Operation Event register clears it.

Query Syntax	STATus:OPERation:EVENt?
Parameters	None
Returned Parameters	<NR1>(Register Value)
Examples	STAT:OPER:EVEN?
Related Commands	*CLS

STATus:OPERation:CONDition?

This query returns the value of the Operation Condition register. This is a read-only register which holds the real-time (unlatched) operational status of the i Series source.

Query Syntax	STATus:OPERation:CONDition?
Parameters	None
Examples	STAT:OPER:COND?
Returned Parameters	<NR1>(Register value)

STATus:OPERation:ENABle

This command and its query set and read the value of the Operation Enable register. This register is a mask for enabling specific bits from the Operation Event register to set the operation summary bit (OPER) of the Status Byte register. The operation summary bit is the logical OR of all enabled Operation Event register bits.

Command Syntax	STATus:OPERation:ENABle <NRf+>
Parameters	0 to 32727
Default Value	0
Examples	STAT:OPER:ENAB 32 STAT:OPER:ENAB 1
Query Syntax	STATus:OPERation:ENABle?
Returned Parameters	<NR1>(Register value)
Related Commands	STAT:OPER:EVEN

Bit Configuration of Questionable Registers

Bit Position	13-15	12	10-11	10	9	8-5	3	2-4	1	0
Bit Name	not used	CL	not used	not used	RI	not used	OT	not used	CF	VF
Bit Weight		4096			512		8		2	1

VF over or under voltage protection has tripped
CF over-current protection has tripped
OT over-temperature protection has tripped
RI remote inhibit is active
CL rms current limit is active

STATus:

This query returns the value of the Questionable Event register. The Event register is a read-only register which holds (latches) all events. Reading the Questionable Event register clears it.

Query Syntax	STATus:QUEStionable[:EVENt]?
Parameters	None
Returned Parameters	<NR1>(Register Value)
Examples	STAT:QUES:EVEN?
Related Commands	*CLS

STATus:QUEStionable:CONDition?

This query returns the value of the Questionable Condition register. That is a read-only register which holds the real-time (unlatched) questionable status of the .

Query Syntax	STATus:QUEStionable:CONDition?
Example	STAT:QUES:COND?
Returned Parameters	<NR1>(Register value)

STATus:QUEStionable:ENABle

This command sets or reads the value of the Questionable Enable register. This register is a mask for enabling specific bits from the Questionable Event register to set the questionable summary (QUES) bit of the Status Byte register. This bit (bit 3) is the logical OR of all the Questionable Event register bits that are enabled by the Questionable Status Enable register.

Command Syntax	STATus:QUESionable:ENABle <NRf+>
Parameters	0 to 32727
Default Value	0
Examples	STAT:QUES:ENAB 18
Query Syntax	STATus:QUEStionable:ENABle?
Returned Parameters	<NR1>(Register value)
Related Commands	STAT:QUES:EVEN?

4.3 System Commands

The system commands control the system-level functions of the i Series AC Source.

4.3.1 Error System Command

Subsystem Syntax

SYSTem	
:ERRor?	Returns the error number and error string
:VERSion?	Returns the SCPI version number
:LANGuage	Sets the programming language
:LOCal	Go to local mode (RS-232 only)
:REMote	Go to remote mode (RS-232 only)
:CONFigure	Set system configuration, password required
:ETIMe?	Returns the elapse time
:COMMunicate	
:GPIB	
:ADDRess	Set GPIB address
:SERial	
:BAUD	Set the baud rate
:PARity	Set the parity type
:BITS	Set number of bits
:SBITs	Set number of stop bits

SYSTem:ERRor?

This query returns the next error number followed by its corresponding error message string from the remote programming error queue. The queue is a FIFO (first-in, first-out) buffer that stores errors as they occur. As it is read, each error is removed from the queue. When all errors have been read, the query returns 0,No Error. If more errors are accumulated than the queue can hold, the last error in the queue is -350,Too Many Errors.

Query Syntax	SYSTem:ERRor?
Parameters	None
Returned Parameters	<NR1>,<SRD>
Example	SYST:ERR?

SYSTem:VERSion?

This query returns the SCPI version number to which the AC/DC source complies. The returned value is of the form YYYY.V, where YYYY represents the year and V is the revision number for that year.

Query Syntax	SYSTem:VERSion?
Parameters	None
Returned Paramters	<NR2>
Example	SYST:VERS?

SYSTem:LANGuage

Sets the command language of the AC Power Source to either SCPI or APE. The language selection is stored in non-volatile memory and is retained after power-off. Both the command and query form can be given regardless of the current language. Refer to the i Series APE programming language reference in appendix D more information.

Command Syntax	SYStem:LANGuage:<language>
Parameters	SCPI or APE
Example	SYST:LANG:SCPI
Query Syntax	SYSTem LANGuage?
Returned Paramters	<CRD>

SYSTem:LOCal

This command can only be used with the RS-232 interface. It sets the interface in Local state, which enables the front panel controls.

Command Syntax	SYSTem:LOCal
Parameters	None
Example	SYST:LOC
Related Commands	SYST:REM

SYSTem:REMote

This command can only be used with the RS-232 interface. It sets the interface in the Remote state, which disables all front panel controls.

Command Syntax	SYSTem:REMote
Parameters	None
Example	SYST:REM
Related Commands	SYST:LOC

SYSTem:CONFigure

This command will set the system configuration. This is a protected command and requires a password. The query response is available however.

Command Syntax	SYSTem:CONFigure
Parameters	SCPI,APE,CLOCK,DO160,MIL704,IEC1001
Example	SYST:CONF SCPI,APE SYST:CONF?
Returned Parameters	<CRD>

SYSTem:ETIMe?

This command will return the total number of accumelated hours, minutes and seconds.

Command Syntax	SYSTem:ETIMe?
Parameters	none
Example	SYST:ETIM?
Returned Parameters	<NR1>,<NR1>,<NR1>

SYSTem:COMMunicate:GPIB:ADDRess

This command will set the GPIB address.

Command Syntax	SYSTem:COMMunicate:GPIB:ADDRess <NRF>
Parameters	0 to 31 <listen address>
Example	SYST:COMM:GPIB:ADDR 2
Returned Parameters	<NR1>

SYSTem:COMMunicate:SERial:BAUD

This command will set the SERial communication baud rate.

Command Syntax	SYSTem:COMMunicate:SERial:BAUD <NRF>
Parameters	1200|2400|4800|9600
Example	SYST:COMM:SER:BAUD 9600
Returned Parameters	<NR1>

SYSTem:COMMunicate:SERial:PARity

This command will set the SERial communication parity.

Command Syntax	SYSTem:COMMunicate:SERial:PARity <parity>
Parameters	NONE|EVEN|ODD
Example	SYST:COMM:SER:PAR NONE
Returned Parameters	<CRD>

SYSTem:COMMunicate:SERial:BITS

This command will set the SERial communication number of bits.

Command Syntax	SYSTem:COMMunicate:SERial:BITS <NRF>
Parameters	7|8
Example	SYST:COMM:SER:BITS 8
Returned Parameters	<NR1>

SYSTem:COMMunicate:SERial:SBITs

This command will set the SERial communication number of stop bits.

Command Syntax	SYSTem:COMMunicate:SERial:SBITs <NRF>
Parameters	1|2
Example	SYST:COMM:SER:SBITs 1
Returned Parameters	<NR1>

4.3.2 Trigger Subsystem

This subsystem controls the triggering of the i Series source. See chapter 5 under "Triggering Output Changes" for an explanation of the Trigger Subsystem. The INITiate commands control the initialization of the transient system.

The trigger subsystem must first be enabled using the INITiate commands or no triggering action will occur.

Subsystem Syntax

ABORt Resets the trigger system to the Idle state	
INITiate	
[:IMMediate]	Initiates the system for one trigger
:CONTinuous	sets if the initate continuous to (ON|OFF)
ARM	
:SOURCe	set the ARM source to (IMMediate|BUS)
TRIGger	
:SOURce <source>	Sets the trigger source (IMMediate|BUS)
:PHASe	Sets the synchronous phase reference
:COUNt	Set if the trigger is controlled at every count(NONE|ALL)
:STATe?	Return the trigger state (IDLE|ARM|BUSY)

ABORt

This command resets the transient trigger systems to the Idle state. Any output transient or measurement that is in progress is immediately aborted. ABORt also cancels any lists or pulses that may be in process.

Command Syntax	ABORt
Parameters	one
Examples	ABOR
Related Commands	INIT *RST *TRG

INITiate:IMMediate

INITiate

The INITiate command controls the initiation of the transient generator trigger system. They cause the trigger system to make a transition from the Idle state to the Waiting-for-Trigger state. If the trigger system is not in the Idle state, the initiate commands are ignored.

Command Syntax	INITiate[:IMMediate]
Parameters	None
Examples	INIT
Related Commands	ABOR INIT:CONT *TRIG

INITiate:CONTinuous

These commands control the transient generator trigger system.

- 1 or ON continuously initiates the transient trigger system.
- 0 or OFF turns off continuous triggering. In this state, the trigger system must be initiated for each triggered event using INITiate:SEQuence.

Command Syntax	INITiate:CONTinuous
Parameters	0|1|OFF|ON
*RST Value	OFF
Examples	INIT:CONT ON
Related Commands	ABOR INIT:CONT *TRG

ARM:SOURce

This command will determine the source of the trigger event. The following sources are available:

- IMMediate Triggering occurs as soon as the INIT command is received.
- BUS Triggering occurs following the INIT command after receiving the *TRG command or a GET IEEE signal.

Command Syntax	ARM:SOURce
Parameters	IMMediate | BUS
*RST Value	IMMediate
Examples	ARM BUS
Related Commands	ABOR <group execute trigger>

TRIGger:SOURce

This commands select the synchronizing trigger source in generating a step, pulse, or list output as follows:

- IMMediate starts the transient output immediately.
- PHASe starts the transient output at the reference phase set by TRIG:PHAS.

Command Syntax	TRIGger:SOURce <CRD>
Parameters	IMMediate|PHASe
*RST Value	IMM
Examples	TRIG: SOUR IMM TRIG:SOUR PHAS
Query Syntax	TRIGger:SOURce?
Returned Parameters	<CRD>
Related Commands	ABOR
	TRIG:PHAS INIT INIT:CONT *TRG

TRIGger:PHASe

This command sets the phase angle with respect to an internal phase reference if TRIGger:SOURce PHASe is selected. The range is from -360 to +360 Degrees.

Command Syntax	TRIGger:PHASe<NRf+>
Parameters	360 to +360
*RST Value	0
Examples	TRIG:PHAS 90
Query Syntax	TRIGger: PHASe?
Returned Parameters	<NR2>
Related Commands	ABOR TRIG:SOUR INIT INIT:CONT *TRG

TRIGger:COUNt

This command determines whether the phase synchronization is accomplished at the begining of the transient list or pulse for every COUNt or at the begining of the transient for the first count only. It accepts the following parameters.

- NONe Synchronization is accomplished once
- ALL synchronization is accomplished for every count.

Command Syntax	TRIGger:COUNt ALL TRIGger:COUNt NONE
Parameters	ALL, NONE
*RST Value	NONE
Examples	TRIG:COUN ALL TRIG:COUN NONE
Query Syntax	TRIG:COUN?
Returned Parameters	<CRD>
Related Commands	ABOR TRIG TRIG:DEL TRIG:SYNC TRIG:SYNC:PHAS INIT INIT:CONT *TRG WAI

TRIG:STATe

This is a query only command. The response will will define the state of the trigger as follows:

- IDLE The trigger is in idle state.
- ARM The trigger is waiting for internal syncronization or external trigger
- BUSY The triggered transient in progress.

Query Syntax	TRIGger:COUNt?
Returned Parameters	<CRD>
Related Commands	ABOR TRIG:SOUR TRIG:PHAS INIT INIT:CONT *TRG

4.4 Common Commands

Common commands begin with an * and consist of three letters (command) or three letters and a ? (query). Common commands are defined by the IEEE 488.2 standard to perform some common interface functions. The 5001i , 10001i and 15001i respond to the required common commands that control status reporting, synchronization, and internal operations. The 5001i , 10001i and 15001i also respond to optional common commands that control triggers, and stored operating parameters.

Common commands and queries are listed alphabetically.If a command has a corresponding query that simply returns the data or status specified by the command, then both command and query are included under the explanation for the command. If a query does not have a corresponding command or is functionally different from the command, then the query is listed separately. The description for each common command or query specifies any status registers affected. Refer to chapter TBD which explains how to read specific register bits and use the information that they return.

Common Commands Syntax

*CLS	Clear status
*ESE <n>	Standard event status enable
*ESE?	Return standard event status enable
*ESR?	Return event status register
*IDN?	Return instrument identification
*OPC	Enable "operation complete" bit in ESR
*OPC?	Return a "1" when operation complete
*OPT?	Return option number
*RCL <n>	Recall instrument state
*RST	Reset
*SAV <n>	Save instrument state
*SRE <n>	Set service request enable register
*SRE?	Return service request enable register
*STB?	Return status byte
*TRG	Trigger
*WAI	Hold off bus until all device commands done

4.4.1 *CLS

This command clears the following registers (see chapter 6 for descriptions of all status registers):

- Standard Event Status
- Operation Status Event
- Questionable Status Event
- Status Byte
- Error Queue

Command Syntax	*CLS
Parameters	None

4.4.2 *ESE

This command programs the Standard Event Status Enable register bits. The programming determines which events of the Standard Event Status Event register (see *ESR?) are allowed to set the ESB (Event Summary Bit) of the Status Byte register. A "1" in the bit position enables the corresponding event. All of the enabled events of the Standard Event Status Event Register are logically ORed to cause the Event Summary Bit (ESB) of the Status Byte Register to be set. See for descriptions of the Standard Event Status registers.

The query reads the Standard Event Status Enable register.

Bit Configuration of Standard Event Status Enable Register

Bit Position	7	6	5	4	3	2	1	0
Bit Name	PON	not used	CME	EXE	DDE	QYE	not used	OPC
Bit Weight	128		32	16	8	4		1

CME	Command error	DDE	Device-dependent error
EXE	Execution error	OPC	Operation complete
PON	Power-on	QYE	Query error

Command Syntax	*ESE <NRf>
Parameters	0 - 255
Power-On Value	128
Example	*ESE 129
Query Syntax	*ESE?
Returned Parameters	<NR1>(Register value)
Related Commands	*ESR? *STB?

4.4.3 *ESR?

This query reads the Standard Event Status Event register. Reading the register clears it. The bit configuration of this register is the same as the Standard Event Status Enable register (see *ESE). See chapter 6for a detailed explanation of this register.

Query Syntax	*ESR?
Parameters	None
Returned Parameters	<NR1>(Register value)
Related Commands	*CLS *ESE *ESE?
	*OPC

4.4.4 *IDN?

This query requests the source to identify itself. It returns the data in four fields separated by commas.

Query Syntax	*IDN?	
Returned Parameters	<AARD>	
	Field	Information
	California Instruments	Manufacturer
	xxxxxx	Model number and letter
	nnnnnn	Serial number or 0
	Rev. xx.xx	Revision levels of firmware
Example	"CALIFORNIA INSTRUMENTS,5001i, 1234, Rev 1.0"	

4.4.5 *OPC

This command causes the interface to set the OPC bit (bit 0) of the Standard Event Status register when the source has completed all pending operations. (See *ESE for the bit configuration of the Standard Event Status registers.) Pending operations are complete when:

- all commands sent before *OPC have been executed. This includes overlapped commands. Most commands are sequential and are completed before the next command is executed. Overlapped commands are executed in parallel with other commands. Commands such as measurement and calibration are overlapped with subsequent commands sent to the i Series source. The *OPC command provides notification that all overlapped commands have been completed.

*OPC does not prevent processing of subsequent commands but Bit 0 will not be set until all pending operations are completed.

The query causes the interface to place an ASCII "1" in the Output Queue when all pending operations are completed.

Command Syntax	*OPC
Parameters	None
Query Syntax	*OPC?
Returned Parameters	<NR1>
Related Commands	*TRIG *WAI

4.4.6 *OPT?

This query requests the AC source to identify any options that are installed. Options are identified by number. A 0 indicates no options are installed.

Query Syntax	*OPT?
Returned Parameters	<CRD>,[<CRD>]

4.4.7 *RCL

This command restores the AC/DC source to a state that was previously stored in memory (including the transient list) with a *SAV command to the specified location. All states are recalled with the following exceptions:

- CAL:STATe is set to OFF
- the trigger system is set to the Idle state by an implied ABORt command (this cancels any uncompleted trigger actions)

Command Syntax	*RCL <NRf>
Parameters	0 through 7
Example	*RCL 3
Related Commands	*RST *SAV

WARNING: ***Recalling a previously stored state may place hazardous voltages at the AC source output.***

4.4.8 *RST

This command resets the AC source to the following factory-defined states:

Table 4-1 : *RST default parameter values

Item	Value	Item	Value
INIT:CONT	OFF	[SOUR:]LIST:STEP	AUTO
OUT	OFF	[SOUR:]PHAS:MODE	FIX
OUTP:PROT:DEL	100ms	[SOUR:]VOLT:TRIG	
OUTP:TTLT	OFF		
OUTP:TTLT:SOUR	BOT		
SENS:CURR:ACDC:RANG	MAX		
[SOUR:]FREQ:MODE	FIX	[SOUR:]VOLT:SLEW:MODE	FIX
[SOUR:]FREQ:SLEW	MAX	[SOUR:]VOLT:SLEW:TRIG	MAX
[SOUR:]FREQ:SLEW:MODE	FIX	TRIG:CONN	NONE
[SOUR:]FREQ:SLEW:TRIG	MAX		
[SOUR:]FREQ:TRIG	60Hz	TRIG:SOUR	IMM
[SOUR:]FUNC:MODE	FIX	TRIG:PHAS	0
		ARM:SOUR	IMM

Command Syntax	*RST
Parameters	None
Related Commands	*SAV

4.4.9 *SAV

This command stores the present state of the i Series source to a specified location in memory. Up to 8 states (including the transient list) can be stored in nonvolatile memory.

Command Syntax	*SAV
Parameters	0 through 7
Related Commands	PSC *RCL *RST

4.4.10 *SRE

This command sets the condition of the Service Request Enable Register. This register determines which bits from the Status Byte Register (see *STB for its bit configuration) are allowed to set the Master Status Summary (MSS) bit and the Request for Service (RQS) summary bit. A 1 in any Service Request Enable Register bit position enables the corresponding Status Byte Register bit and all such enabled bits then are logically ORed to cause Bit 6 of the Status Byte Register to be set. See chapter TBD for more details concerning this process.

When the controller conducts a serial poll in response to SRQ, the RQS bit is cleared, but the MSS bit is not. When *SRE is cleared (by programming it with 0), the source cannot generate an SRQ to the controller.

Command Syntax	*SRE <NRf>
Parameters	0 to 255
Default Value	128
Example	*SRE 255
Query Syntax	*SRE?
Returned Paramters	<NR1>(Register binary value)
Related Commands	*ESE *ESR

4.4.11 *STB?

This query reads the Status Byte register, which contains the status summary bits and the Output Queue MAV bit. Reading the Status Byte register does not clear it. The input summary bits are cleared when the appropriate event registers are read (see chapter 6 for more information). A serial poll also returns the value of the Status Byte register, except that bit 6 returns Request for Service (RQS) instead of Master Status Summary (MSS). A serial poll clears RQS, but not MSS. When MSS is set, it indicates that the source has one or more reasons for requesting service.

Bit Configuration of Status Byte Register

Bit Position	7	6	5	4	3	2 - 0
Bit Name	OPER	MSS RQS	ESB	MAV	QUES	not used
Bit Weight	128	64	32	16	8	

OPER operation status summary
ESB event status byte summary
QUES questionable status summary
MSS master status summary
RQS request for service
MAV message available

Query Syntax	*STB?
Returned Paramters	<NR1> (Register binary value)
Related Commands	*SRE *ESE *ESR

4.4.12 *TRG

This command generates a trigger to any subsystem that has BUS selected as its source (for example, TRIG:SOUR BUS).The command has the same affect as the Group Execute Trigger (<GET>) command.

Command Syntax	*TRG
Parameters	None
Related Commands	ABOR INIT

4.4.13 *WAI

This command instructs the AC source not to process any further commands until all pending measurement and calibration operations are completed. Pending operations are complete when:

- all commands sent before *WAI have been executed. This includes overlapped commands. Most commands are sequential and are completed before the next command is executed. Overlapped commands are executed in parallel with other commands. Commands that affect output voltage or state, relays, and trigger actions are overlapped with subsequent commands sent to the AC source. The *WAI command prevents subsequent commands from being executed before any overlapped commands have been completed.

- all triggered actions are completed and the trigger system returns to the Idle state.

*WAI can be aborted only by sending the an IEEE-488 DCL (Device Clear) command.

Command Syntax	*WAI
Parameters	None
Related Commands	*OPC

5. Programming Examples

5.1 Introduction

This chapter contains examples on how to program the AC/DC source. Simple examples show you how to program:

- output functions such as voltage, frequency, and phase
- the transient waveform generator
- internal and external triggers
- measurement functions
- user-defined waveforms
- the status and protection functions

The examples in this chapter use generic SCPI commands. See chapter 2 for information about encoding the commands as language strings. Where appropriate, optional commands are shown for clarity in the examples.

5.2 Programming the Output

Power-on Initialization

When the AC source is first turned on, it wakes up with the output state defined by the PONSetup. In this state the output voltage is set to a value defined by the INIT:VOLT. The following commands are given implicitly at power-on:

*RST
*CLS
*SRE 0
*ESE 0

*RST is a convenient way to program all parameters to a known state. Refer to Table 4-1 under the *RST command in paragraph 4.4.8 to see how each programmable parameter is set by *RST.

Enabling the Output

To enable the output, use the command:

OUTPut ON

AC Voltage and Frequency

The AC rms output voltage is controlled with the VOLTage command. For example, to set the AC output voltage to 125 volts rms, use:

VOLTage 125

The DC output voltage is controlled with the VOLTage:DC command. For example, to set the DC output voltage to 100 volts DC, use:

VOLTage:DC 100

The AC/DC source can be programmed to turn off its output if the output voltage does not agree with the set value.

Maximum Voltage

The maximum rms output voltage that can be programmed can be queried with:

VOLTage? MAX

The maximum voltage that the AC/DC source can output is limited by the rms value of the waveform. This value is defined by the LIMIT subsystem.

Voltage Ranges

The power source has two voltage ranges that are controlled by relay. The command that controls the range is:

VOLTage:RANGe MIN | MAX | 135 | 270

When the range is set to MIN (or 135), the maximum rms voltage that can be programmed for a sine wave is 135 volts rms, but it is only on this range that the maximum output current rating is available.

The VOLTage:RANGe command is coupled with the CURRent command. This means that the maximum current limit that can be programmed at a given time depends on the voltage range setting in which the unit is presently operating.

Frequency

The output frequency is controlled with the FREQuency command. To set the output frequency to 50 Hz, use:

FREQuency 50

Voltage and Frequency Slew Rates

Voltage Slew

The AC source has the ability to control the slew rate of AC amplitude and frequency changes and dc amplitude. This can be used to generate ramps or to protect sensitive loads. To set the voltage slew rate to 20 volts per second, use:

VOLTage:SLEW 20

At *RST the slew rate is set to Maximum, which means that AC voltage changes occur at the fastest possible slew rate. The slew rate applies to programmed changes in AC/DC output amplitude while the unit is operating in fixed mode. Amplitude changes made by the step, pulse, and list transients are controlled by the same rules that apply to all other functions that are subject to transient control. See "Programming Output Transients".

Frequency Slew

The AC source also has the ability to control the slew rate of frequency changes. To set the frequency slew rate to 30 Hz per second, use:

FREQuency:SLEW 30

At *RST the slew rate is set to MAXimum, which means that frequency changes occur instantaneously. The frequency slew rate applies to programmed changes in frequency while the unit is operating in fixed mode. Frequency changes made by the step, pulse, and list transients are controlled by the same rules that apply to all other functions that are subject to transient control. See "Programming Output Transients".

Programming the Output Phase

You can control the phase of the AC voltage waveform relative to an external reference with:

PHASe <n>

which sets the phase in degrees. If <n> is positive, the voltage waveform leads the internal reference.

In the 5001i, 10001i and the 1500iL, the PHASe command sets the relative phase of each of the outputs in three phase configuration

Current Limit

This command will set the rms current limit, to set this limit is:

CURRent <n>

where <n> is the rms current limit in amperes.

If the load attempts to draw more current than the programmed limit, and the source is set for constant current mode, the output voltage is reduced to keep the rms current within the limit. Since the rms detection involves a filter time constant that is long compared to a single output cycle, the response time of the rms current limit is not instantaneous.

The AC source can be programmed to turn off its output if the rms current limit is reached. This protection feature is activated when the source mode is set for constant voltage mode.

Note:	***The CURRent command is coupled with the VOLTage:RANGe.This means that the maximum current limit that can be programmed at a given time depends on the voltage range setting in which the unit is presently operating. Refer to "Coupled Commands" for more information.***

5.3 Coupled Commands

This section describes how to avoid programming errors that may be caused by the error checking done for coupled commands such as VOLTage:LEVel.

Commands that are coupled to the VOLTage command are the output transient commands that control step, pulse and list generation. When an output transient is initiated (ready to receive a trigger), the error checking that takes place for maximum rms voltage.

CURRent:LEVel and VOLTage:RANGe

Programming the current limit by itself to a value that is greater than the maximum allowed on the presently programmed voltage range causes an error. If the commands

VOLTage:RANGe 270

CURRent 40

are sent, an error will be generated because the CURRent command is requesting a current limit that is outside the maximum value allowed on that voltage range.

Programming the VOLTage:RANGe by itself causes the programmed current limit to be set to the maximum for the given range if it had previously been higher than the maximum setting for the new range. If the commands

VOLTage:RANGe 135

CURRent 37

VOLTage:RANGe 270

are sent, no error will be generated because the second VOLTage:RANGe command automatically sets the programmed current limit to 18.5, which is the maximum value for the programmed voltage range.

Programming both the current and the voltage range in one program message unit can be done based on the order and the initial voltage setting. If the following commands are send:

VOLTage:RANGe 270

CURRent 44;:VOLTage:RANGe 135; :CURRent 37

no error will be generated because the combined current limit and voltage range specified on the second line are within the output ratings of the power source, but the voltage range command must be set before the current command.

5.4 Programming Output Transients

Output transients are used to:

- Synchronize output changes with a particular phase of the voltage waveform.
- Synchronize output changes with internal or external trigger signals.
- Simulate surge, sag, and dropout conditions with precise control of duration and phase.
- Create complex, multi-level sequences of output changes.
- Create output changes that have rapid or precise timing requirements.

The following AC/DC source functions are subject to transient control:

- AC output voltage
- DC output voltage
- Frequency
- Start phase angle
- AC/DC voltage slew rate
- Frequency slew rate

The following transient modes can be generated:

Step	generates a single triggered output change.
Pulse	generates an output change which returns to its original state after some time period.
List	generates a sequence of output changes, each with an associated dwell time or paced by triggers.
Fixed	turns off the transient functions, which means that only the IMMediate values are used as the data source for a particular function.

At *RST all functions are set to FIXed, which turns off the transient functions.

5.4.1 Transient System Model

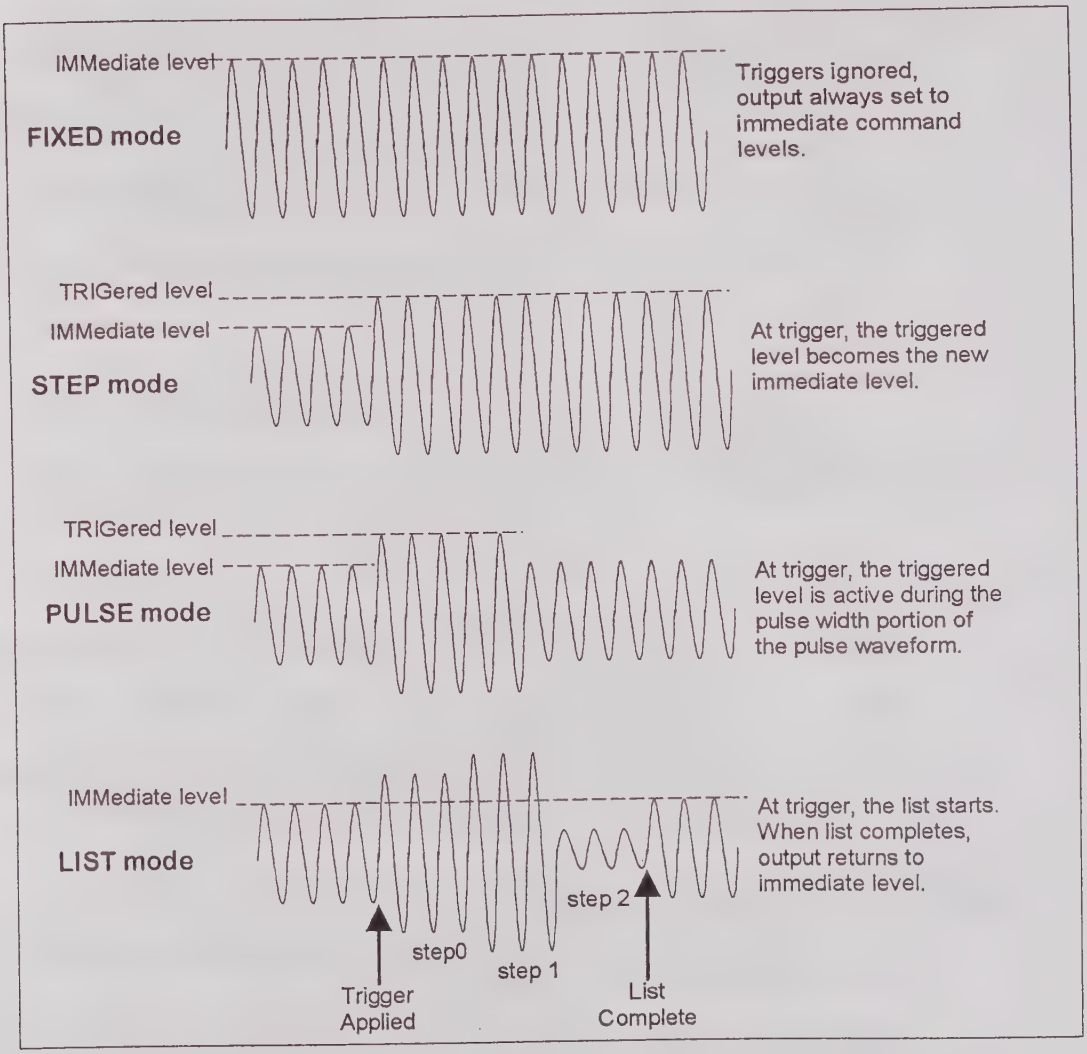
Figure 5-1shows a model of the transient system. The figure shows the transient modes and the source of the data that generates each mode.

When a trigger is received in step or pulse modes, the triggered functions are set from their IMMediate to their TRIGgered value. In Step mode, the triggered value becomes the immediate value. In Pulse mode, the functions return to their immediate value during the low portion of the pulse.

If there are no further pulses, the immediate value remains in effect. In List mode, the functions remain at the last list value at the completion of the list.

You can not mix STEP, PULSe, and LIST modes among functions.

Figure 5-1 : Model of Transient System


IMMediate level
FIXED mode
Triggers ignored, output always set to immediate command levels.
TRIGered level
IMMediate level
STEP mode
At trigger, the triggered level becomes the new immediate level.
TRIGered level
IMMediate level
PULSE mode
At trigger, the triggered level is active during the pulse width portion of the pulse waveform.
IMMediate level
LIST mode
At trigger, the list starts. When list completes, output returns to immediate level.
step 2
step0
step 1
Trigger Applied
List Complete

5.4.2 Step and Pulse Transients

Step 1 : Set the functions that you do not want to generate transients to FIXed mode. A convenient way to do this is with the *RST command. Then set the mode of the function that will generate the transient to STEP or PULSe as required. For example, to enable the voltage function to generate a single triggered output voltage change, use:

*RST

VOLTage:MODE STEP

Step 2 : Set the triggered level of the function that will generate the transient. For example, if the previously programmed voltage function is going to step the output voltage amplitude to 135 volts upon reciept of a trigger, use:

VOLTage:TRIGger 135

Step 3 : Select the trigger source that will generate the trigger. For example, to select the Immediate use:

TRIGger:SOURce IMM

Trigger sources are discussed in detail under "Triggering Output Changes"

Step 4 : Only perform this step if you have selected PULSE as the transient mode in Step 1. Specify the pulse count, the pulse period, and then either the duty cycle or the pulse width using the following commands:

PULSe:COUNt 1	specifies 1 output pulse
PULSe:PERiod 1	specifies a pulse period of 1 second
PULSe:DCYCle 50	specifies a duty cycle of 50%
PULSe:WIDTh .5	specifies a pulse width of .5 seconds (not necessary in this case since a duty cycle has already been specified)

Step 5 : Initiate the transient trigger system to enable it to receive a trigger. To enable the trigger system for one transient event use:

INITiate

Example

The following example programs a voltage dropout for 2 cycles of a 120 volt, 60 Hz output. The dropout begins at the positive peak of the output voltage waveform (90 degrees phase) and is triggered by IEEE-488 bus trigger.

*RST	Begin at power-on state
VOLT 120	Set initial output voltage (immediate-level)
FREQ 60	Set initial output frequency
OUTP ON	Enable the output
VOLT:MODE PULS	Enable output to generate pulses when triggered
VOLT:TRIG 0	Set the voltage dropout (triggered level)
PULS:WIDT .03333	Set pulse width for 2 periods
PULS:PER 0.0667	Set pulse period for 4 cycles
TRIG:ARM:SOUR BUS	Respond to IEEE-488 bus triggers
TRIG:SOUR:PHAS	Synchronize triggers to internal phase reference

TRIG:PHAS 90	Sets internal phase reference point to 90 degrees
INIT	Set to Wait-for-trigger state
<device trigger>	Send the IEEE-488 bus trigger

5.4.3 List Transients

List mode lets you generate complex sequences of output changes with rapid, precise timing, which may be synchronized with internal or external signals. Each function that can participate in output transients can also have an associated list of values that specify its output at each list point.

You can program up to 32 settings (or points) in the list, the time interval (dwell) that each setting is maintained, the number of times each data point is repeated, the number of times that the list will be executed, and how the settings change in response to triggers.

All list point data could be stored in nonvolatile memory in specific register. This means that the programmed data for any list function will be retained when it is saved in the register when the AC source is turned off.

Lists are paced by a separate list of dwell times which define the duration of each output setting. Therefore, each of the up to 32 list points has an associated dwell time, which specifies the time (in seconds) that the output remain at that setting before moving on to the next setting.

The following procedure shows how to generate a simple list of voltage and frequency changes.

Step 1 : Set the mode of each function that will participate in the output sequence to LIST. For example:

VOLTage:MODE LIST

FREQuency:MODE LIST

Step 2 : Program the list of output values for each function. The list commands take a comma-separated list of arguments. The order in which the arguments are given determines the sequence in which the values will be output. For example, to cycle the voltage through a sequence that includes nominal line, high line, and low line, a list may include the following values:

LIST:VOLTage 120, 132, 108, 120, 132, 108, 120, 132, 108, 120

You can specify lists for more than one function. For example, to synchronize the previous voltage list with another list that varies the output frequency from nominal, to high, to low, the lists may include the following values:

LIST:VOLTage 120, 132, 108, 120, 132, 108, 120, 132, 108, 120

LIST:FREQuency 60, 60, 60, 63, 63, 63, 57, 57, 57,60

All lists must have the same number of data values or points, or an error will occur when the transient system that starts the sequence is later initiated. The exception is when a list has only one item or point. In this case the single-item list is treated as if it had the same number of points as the other lists, with all values being equal to the one item. For example:

LIST:VOLTage 110, 120, 130;FREQuency 60

is the same as:

LIST:VOLTage 110, 120, 130

LIST:FREQuency 60, 60, 60, 60

Step 3 : Determine the time interval that the output remains at each level or point in the list before it advances to the next point. The time is specified in seconds. For example, to specify five dwell intervals, use:

LIST:DWELl 1, 1.5, 2, 2.5, 3,1

The number of dwell points must equal the number of output points. If a dwell list has only one value, that value will be applied to all points in the output list.

Step 4 : Determine the number of times the list is repeated before it completes. For example, to repeat a list 10 times use:

LIST:COUNt 10

At *RST, the count is set to 1.

Step 5 : Determines how the list sequencing responds to triggers. For a closely controlled sequence of output levels, you can use a dwell-paced list. To cause the list to be paced by dwell time use:

LIST:STEP AUTO

As each dwell time elapses, the next point is immediately output. This is also the *RST setting.

If you need the output to closely follow asynchronous events, then a trigger-paced list is more appropriate. In a trigger-paced list, the list advances one point for each trigger received. To enable trigger-paced lists use:

LIST:STEP ONCE

The dwell time associated with each point determines the minimum time that the output remains at that point. If a trigger is received before the previous dwell time completes, the trigger is ignored. Therefore, to ensure that no triggers are lost, program the dwell time minimum.

Step 6 : Use the transient trigger system to trigger the list. This is described in detail under "Triggering Output Changes"

5.5 Triggering Output Changes

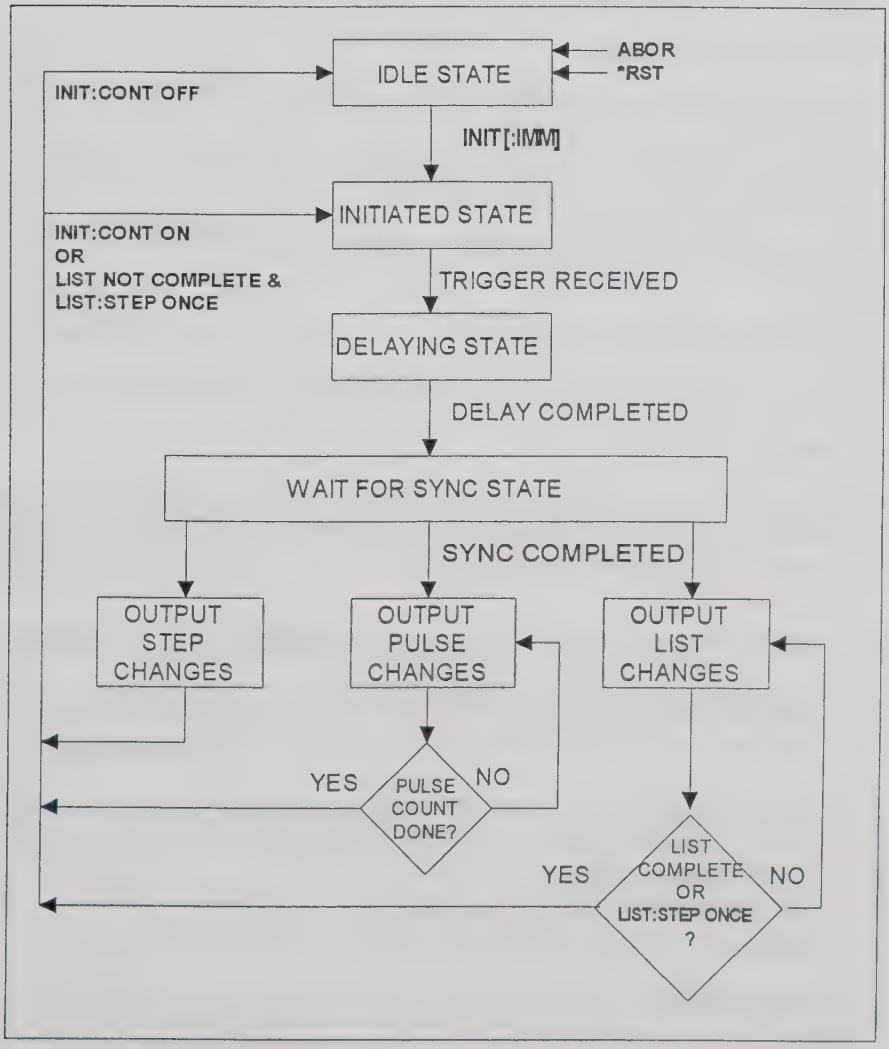
The following transient trigger arm sources can be selected:

IMMediate	generates a trigger when the trigger system is initiated.
BUS	selects IEEE-488 bus triggers.

5.5.1 Trigger System Model

Figure 4-2 is a model of the trigger system. The rectangular boxes represent states. The arrows show the transitions between states. These are labeled with the input or event that causes the transition to occur.

Figure 5-2 : Trigger System Model



5.5.2 Initiating the Output Trigger System

When the source is turned on, the trigger subsystem is in the idle state. In this state, the trigger subsystem ignores all triggers. Sending the following commands at any time returns the trigger system to the Idle state:

ABORt *RST

The INITiate commands move the trigger system from the Idle state to the Initiated state. This enables the AC source to receive triggers. To initiate for a single triggered action, use:

INITiate:IMMediate

After a trigger is received and the action completes, the trigger system will return to the Idle state. Thus it will be necessary to initiate the system each time a triggered action is desired. To keep a trigger system initiated for multiple actions without having to send an initiate command for each trigger, use:

INITiate:CONTinuous:

Selecting the Trigger Arm

The trigger system is waiting for a trigger signal in the Initiated state. Before you generate a trigger, you must select a trigger arm source.

To select IEEE-488 bus triggers (group execute trigger, device trigger, or *TRG command), use:

TRIGger:ARM:SOURce

To select a trigger source that is always true, use:

TRIGger:ARM:SOURce

The immediate source can be combined with INITiate:CONTinuous ON to generate repetitive output transients. A transition from the Initiated state to the Delay state is made when the trigger signal is received.

5.5.3 Synchronizing Output Changes to a Reference Phase Angle

An output transient normally occurs immediately when the trigger signal is received. For some applications it is desirable for the transient to be synchronized with a particular phase of the output waveform such as the zero crossing point (0°) or the positive peak (90°).

To synchronize the start of a transient with a particular phase angle of the internal phase reference, you must select PHASE as the trigger source. Use:

TRIGger:SOURce PHASe

To select the desired phase, use:

TRIGger: PHASe 90

which specifies the 90 degree phase angle of the internal phase reference as the point where the transient begins.

To turn off transient phase synchronization, use:

TRIGger: SOURce IMMediate

When IMMediate is selected, the trigger system goes directly to the Output state. This is the parameter selected at *RST.

5.5.4 Generating Triggers

Providing that you have specified the appropriate trigger source, you can generate triggers as follows:

Single Triggers

By sending one of the following over the IEEE-488:

- INIT
- *TRG
- a group execute trigger

Continuous Triggers

By sending the following commands over the IEEE-488:

- TRIGger:ARM:SOURce IMMediate
- INITiate:CONTinuous ON

When the trigger system enters the Output Change state upon receipt of a trigger (see Figure 5-2 : Trigger System Model), the triggered functions are set to their programmed trigger levels. When the triggered actions are completed, the trigger system returns to the Idle state.

Specifying a Dwell Time for Each List Point

Each voltage and frequency list point has an associated dwell time specified by:

LIST:DWELI <n> ,<n>

where <n> specifies the dwell time in seconds. The number of dwell points must equal the number of output points. If a dwell list has only one value, that value will be applied to all points in the output list. After each new output level or point is programmed, the output remains at that point in the list for the programmed dwell interval before the list advances to the next point. Only an ABORt command can transfer the system out of the Dwelling state.

At the end of the dwell interval, the transition to the next state depends on whether or not the list has completed its sequencing and the state of the LIST:STEP command (see Figure 5-2 : Trigger System Model).

If the list is completed, the trigger system returns to the Idle state.

If the list is not completed, then the system reacts as follows:

LIST:STEP ONCE	programs the trigger system to return to the Initiated state to wait for the next trigger.
LIST:STEP AUTO	programs the trigger system to immediately execute the next list point.

5.6 Making Measurements

The source has the capability to return a number of current, voltage, and power measurements.

The query response for measurements is not immediate. The source will accept command from the interface while the measurement in progress. To prvent the source from accepting command during measurement the *WAI must be used with the measurement query command.

MEAS:FREQ?;*WAI

5.6.1 Voltage and Current Measurements

To the rms voltage or current, use:

MEASure:VOLTage?or

MEASure:CURRent?

To measure the dc voltage or current, use:

MEASure:VOLTage:DC?or

MEASure:CURRent:DC?

To measure the maximum current amplitude and the current crest factor, use:

MEASure:CURRent:AMPLitude:MAXimum?

MEASure:CURRent:CRESTfactor?

To reset the peak measuremnt , use

MEAS:CURR:AMPL:RESet

5.6.2 Power Measurements

The MEASure queries can return real, and apparent power measurements as well as dc power and power factor using the following commands:

MEASure:POWer:AC:APParent?	measures the AC component of apparent power in VA
MEASure:POWer:AC:REAL?	measures the in-phase component of power in watts
MEASure:POWer:AC:PFACtor?	returns the output power factor
MEASure:POWer:DC?	measures the dc component of power

5.6.3 Frequency Measurements

To measure the frequency, use the following command:

MEASure:FREQuency?

6. Status Registers

You can use status register programming to determine the operating condition of the AC source at any time. For example, you may program the AC source to generate an interrupt (assert SRQ) when an event such as a current limit occurs. When the interrupt occurs, your program can then act on the event in the appropriate fashion.

Figure 6-1 : i Series Status System Model

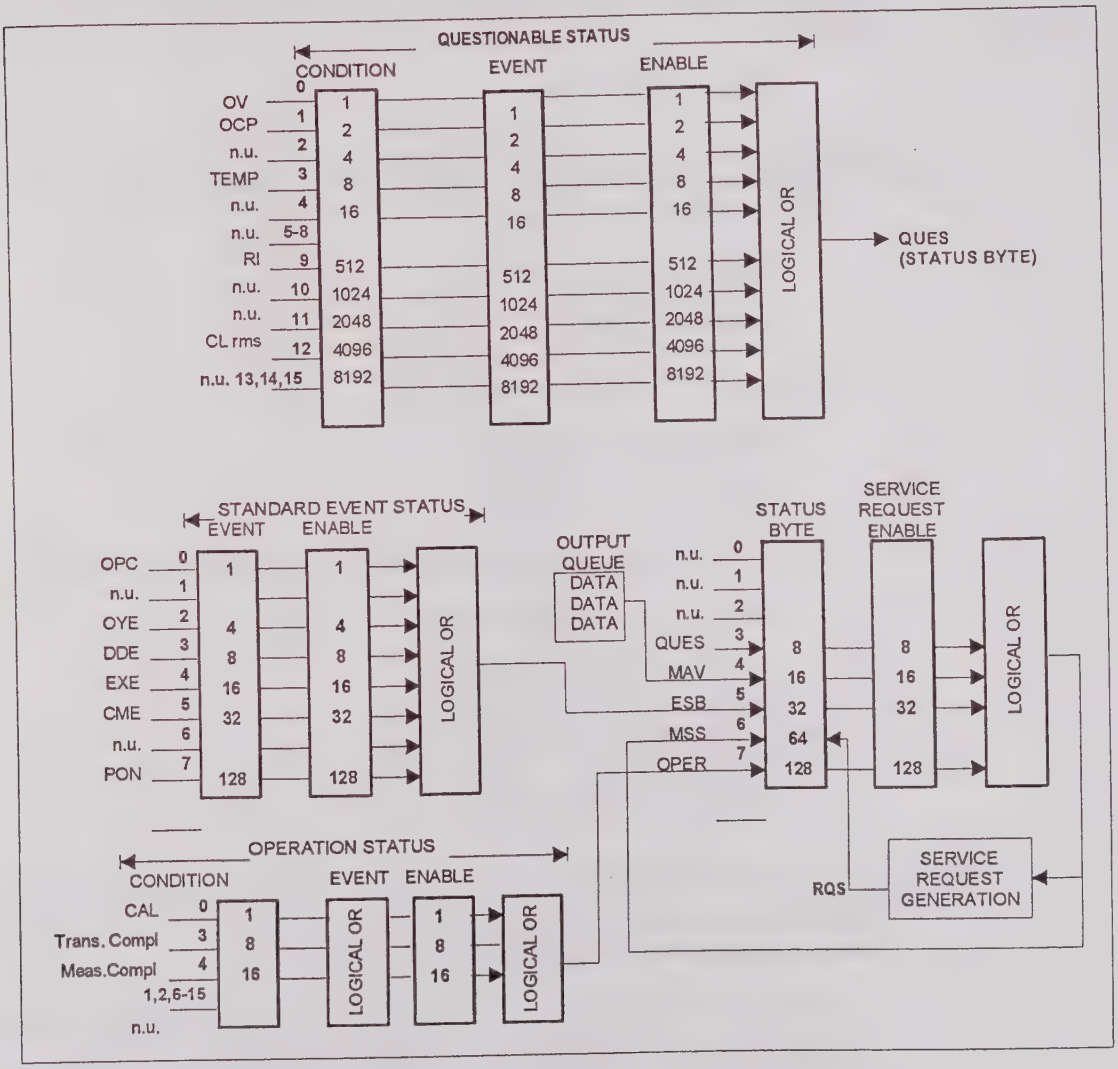


Figure 6-1 shows the status register structure of the AC source.

Table 4-1defines the status bits. The Standard Event, Status Byte, and Service Request Enable registers and the Output Queue perform standard IEEE-488 functions as defined in the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. The Operation Status, and the Questionable Status registers, implement functions that are specific to the source.

6.1 Power-On Conditions

Refer to the *RST command description in paragraph 4.4.8 for the power-on conditions of the status registers.

6.2 Operation Status Group

The Operation Status registers record signals that occur during normal operation. The group consists of the following registers:

Register	Command	Description
Condition	STAT:OPER:COND?	A register that holds real-time status of the circuits being monitored. It is a read-only register.
Event	STAT:OPER:EVEN?	A register that latches any condition. It is a read-only register that is cleared when read.
Enable	STAT:OPER:ENAB <n>	A register that functions as a mask for enabling specific bits from the Event register. It is a read/write register.

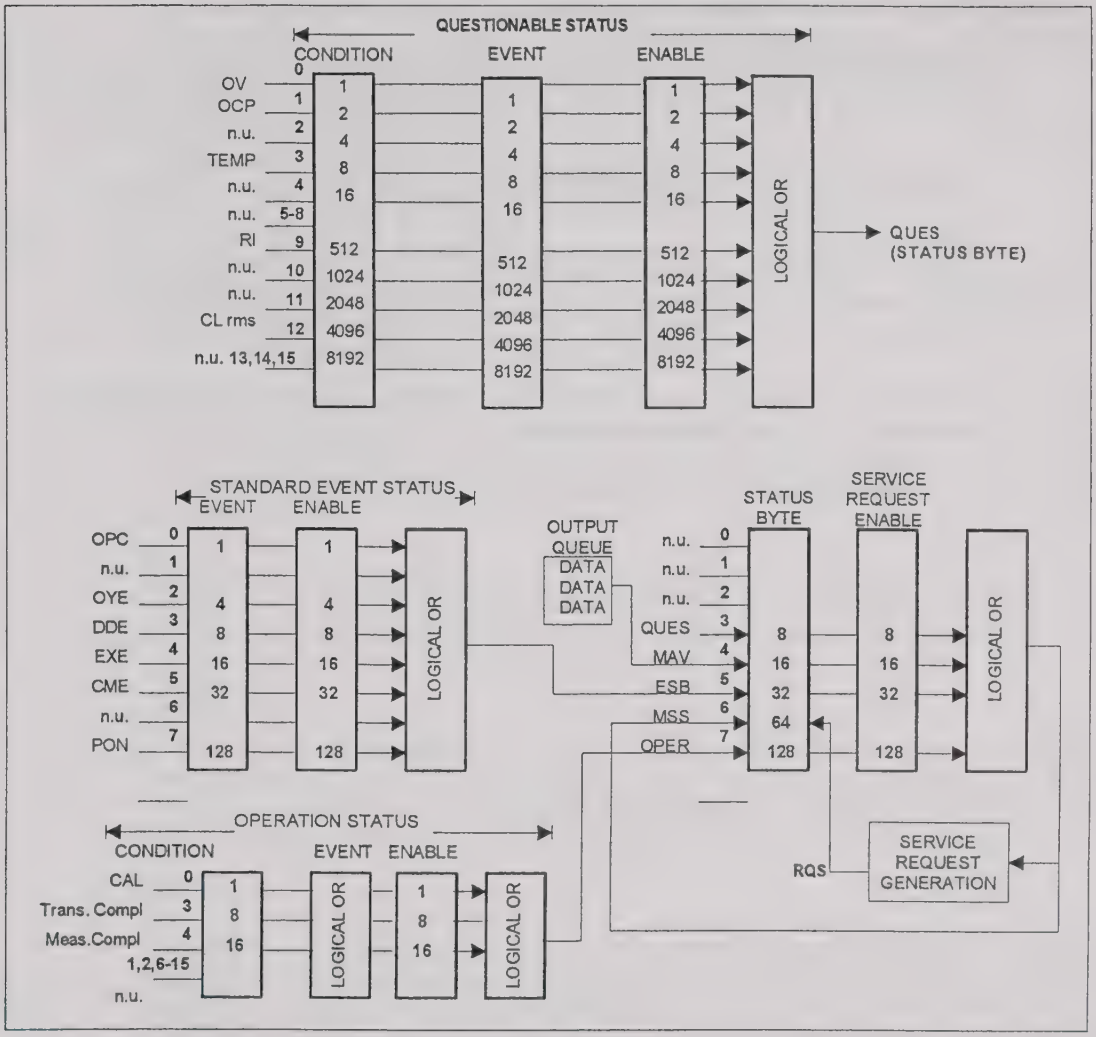
Table 6-1 : Operation Status Register

The outputs of the Operation Status register group are logically-ORed into the OPER(ation) summary bit (7) of the Status Byte register.

Table 6-2 : Bit Configuration of Status Register

Bit	Signal	Meaning
Operation Status Group		
0	CAL	Interface complete its calibration cycle
3	TRANS	Transient is completed
4	MEAS	Measurement is completed
Questionable and Questionable Instrument Isummary Status Groups		
0	OV	Output voltage faulted, output voltage differ from program value
1	OCP	The overcurrent protection circuit has tripped
3	TO	An overtemperature condition has occurred
9	RI	The remote shut down state is active
12	Clrms	The rms current limit circuit is active
14	n/a	
Standard Event Status Group		
0	OPC	Operation complete
2	QYE	Query error
3	DDE	Device-dependend error
4	EXE	Execution error
5	CME	Command error
7	PON	Power-on
Status Byte and Service Request Enable Registers		
3	QUES	Questionable status summary bit
4	MAV	Message Available summary bit
5	ESB	Event Status Summary bit
6	MSS	Master Status Summary bit
	RQS	Request Service bit
7	OPER	Operation status summary bit

Figure 6-1 : i Series Status System Model



6.3 Questionable Status Group

The Questionable Status registers record signals that indicate abnormal operation of the AC source. As shown in Figure 6-1, the group consists of the same type of registers as the Status Operation group.

Register	Command	Description
Condition	STAT:QUES:COND?	A register that holds real-time status of the circuits being monitored. It is a read-only register.
Event	STAT:QUES:EVEN?	A register that latches any condition. It is a read-only register that is cleared when read.
Enable	STAT:QUES:ENAB <n>	A register that functions as a mask for enabling specific bits from the Event register. It is a read/write register.

Table 6-3 : Questionable Status Register

The outputs of the Questionable Status group are logically-ORed into the QUEStionable summary bit (3) of the Status Byte register.

6.4 Standard Event Status Group

This group consists of an Event register and an Enable register that are programmed by Common commands. The Standard Event register latches events relating to interface communication status (see figure 4-5). It is a read-only register that is cleared when read. The Standard Event Enable register functions similarly to the enable registers of the Operation and Questionable status groups.

Command	Action
*ESE	programs specific bits in the Standard Event Enable register.
*ESR?	reads and clears the Standard Event Event register.

The PON bit in the Standard Event Event register is set whenever the AC source is turned on. The most common use for PON is to generate an SRQ at power-on following an unexpected loss of power.

6.5 Status Byte Register

This register summarizes the information from all other status groups as defined in the IEEE 488.2 Standard Digital Interface for Programmable Instrumentation. The bit configuration is shown in Table 4-1.

Command	Action
*STB?	reads the data in the register but does not clear it (returns MSS in bit 6)
serial poll	reads and clears the data in the register (returns RQS in bit 6)

The MSS Bit

This is a real-time (unlatched) summary of all Status Byte register bits that are enabled by the Service Request Enable register. MSS is set whenever the AC source has one or more reasons for requesting service. *STB? reads the MSS in bit position 6 of the response but does not clear any of the bits in the Status Byte register.

The RQS Bit

The RQS bit is a latched version of the MSS bit. Whenever the AC source requests service, it sets the SRQ interrupt line true and latches RQS into bit 6 of the Status Byte register. When the controller does a serial poll, RQS is cleared inside the register and returned in bit position 6 of the response. The remaining bits of the Status Byte register are not disturbed.

The MAV bit and Output Queue

The Output Queue is a first-in, first-out (FIFO) data register that stores AC source-to-controller messages until the controller reads them. Whenever the queue holds one or more bytes, it sets the MAV bit (bit 4) of the Status byte register.

6.6 Examples

The following section contains examples of commonly used operations involving the status registers.

6.6.1 Determining the Cause of a Service Interrupt

You can determine the reason for an SRQ by the following actions:

Step 1 : Determine which summary bits are active.Use

*STB? or serial poll

Step 2 : Read the corresponding Event register for each summary bit to determine which events caused the summary bit to be set. Use:

STATus:QUEStionable:EVENt?

STATus:OPERation:EVENt?

ESR?

Note:	***When an Event register is read, it is cleared. This also clears the corresponding summary bit.***

Step 3 : Remove the specific condition that caused the event. If this is not possible, the event may be disabled by programming the corresponding bit of the status group Enable. A faster way to prevent the interrupt is to disable the service request by programming the appropriate bit of the Service Request Enable register.

6.6.2 Servicing Questionable Status Events

This example assumes you want a service request generated whenever the AC source's overvoltage, overcurrent, or overtemperature circuits have tripped. From Figure 6-1, note the required path for Questionable Status conditions at bits 0, 1, and 3 to generate a service request (RQS) at the Status Byte register. The required register programming is as follows:

Step 1 : Program the Questionable Status Enable register to allow the latched events to be summed into the QUES summary bit. Use:

```
STATus:QUEStionable:ENABle 11
```

Step 2 : Program the Service Request Enable register to allow the QUES summary bit from the Status Byte register to generate RQS. Use:

```
*SRE 8
```

Step 3 : When you service the request, read the event register to determine which Questionable Status Event register bits are set and clear the register for the next event. Use:

```
STATus:QUEStionable:EVENt?
```

6.7 SCPI Command Completion

SCPI commands sent to the AC source are processed either sequentially or in parallel. Sequential commands finish execution before a subsequent command begins. Parallel commands allow other commands to begin executing while the parallel command is still executing. Commands that affect list and trigger actions measurements and calibration are among the parallel command.

The *WAI, *OPC, and *OPC? common commands provide different ways of indicating when all transmitted commands, including any parallel ones, have completed their operations. The syntax and parameters for these commands are described in chapter 4. Some practical considerations for using these commands are as follows:

*WAI	This prevents the AC source from processing subsequent commands until all pending operations are completed except for transients.
*OPC?	This places a 1 in the Output Queue when all pending operations have completed. Because it requires your program to read the returned value before executing the next program statement, *OPC? can be used to cause the controller to wait for commands to complete before proceeding with its program.
*OPC	This sets the OPC status bit when all pending operations have completed. Since your program can read this status bit on an interrupt basis, *OPC allows subsequent commands to be executed.
TRIG:STATe?	This query will report the state of the trigger subsystem and will return IDLE, ARM or BUSY to allow the user monitor the state of the trigger system.

Appendix A: SCPI Command tree

Command Syntax Tree

Appendix B: SCPI Conformance Information

SCPI Version

The i Seris AC power sources conform to SCPI version 1990.0.

SCPI Confirmed commands

Non-SCPI commands.

Appendix C: Error Messages

Error Number	Error Message String
0	"No error"
-100	"Command error"
-102	"Syntax error"
-103	"Invalid separator"
-104	"Data type error"
-108	"Parameter not allowed"
-109	"Missing parameter"
-110	"Command header error"
-111	"header separator error"
-112	"Program mnemonic too long"
-113	"Undefined header"
-120	"Numeric data error"
-121	"Invalid character in number"
-123	"Exponent too large"
-128	"Numeric data not allowed"
-168	"Block data not allowed"
-200	"Execution error"
-201	"Invalid while in local"
-203	"Command protected"
-210	"Trigger error"
-211	"Trigger ignored"
-213	"Init ignored"
-220	"Parameter error"
-221	"Setting conflict"
-222	"Data out of range"
-223	"Too much data"
-224	"Illegal parameter value"

Error Number	Error Message String
-226	"Lists not same length"
-241	"Hardware missing"
-254	"Media full"
1	"Output volt fault"
2	"Current limit fault"
3	"Temperature fault"
4	"External sync. error"
5	"Initial memory lost"
6	"Limit memory lost"
7	"System memory lost"
8	"Calibration memory lost"
9	"Start angle must be first sequence"
10	"Illegal for DC"
11	"Duplicate sequence"
12	"Too many sequence"
13	"Missing list parameter"
14	"Voltage polarity conflict"
15	"Slew time exceed dwell"
16	"Illegal during transient"
17	"Output relay must be closed"
18	"Trans. duration less then 1msec"
19	"Clock and sync must be internal"
20	"Input buffer full"
-300	"Device specific error"
-311	"Memory error"
-314	"Save/recall memory lost"
-315	"Configuration memory lost"
-330	"Self-test failed"
-350	"Queue overflow"

Error Number	Error Message String
-400	"Query error"
-410	"Query INTERRUPTED"
-420	"Query UNTERMINATED"
-430	"Query DEADLOCKED"
-440	"Query UNTERMINATED"

Table 6-4 : Error Messages

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